International Diversification Benefits with Foreign Exchange Investment Styles*

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Abstract

This paper studies portfolio choice with popular foreign exchange (FX) investment styles such as carry trades, FX momentum and FX value strategies. We go beyond the benefits from hedging to shed more light on the speculative component of currency investments. In particular, we are interested in the magnitude of diversification benefits due to the style-based management of the currency component of well-diversified international portfolios. Our results suggest that FX investment styles generate significant improvements in the asset allocation. These findings hold after taking into account transaction costs and when controlling for the FX risk inherent in the benchmark assets. Importantly, these results are also confirmed in an extensive out-of-sample experiment mimicking investor decisions in real-time.

JEL-Classification: F31, G12, G15

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1 Introduction

Unsurprisingly, the discovery of various foreign exchange (FX) market "anomalies" (e.g. Froot and Thaler, 1990) since the end of the Bretton Woods period has generated considerable interest by researchers and investors. Similar to value and momentum in equity markets, various investment styles have been devised to exploit the market anomalies documented in FX markets. While style-based investments and their role for portfolio allocation in equity markets have been widely studied (e.g. Eun, Huang, and Lai, 2008, or Eun, Lai, de Roon, and Zhang, 2010), however, there is considerably less knowledge about the portfolio implications of style investing in FX markets.

In this paper, we provide a comprehensive analysis of portfolio choice with three widely practiced FX investment styles. We go beyond well-known carry trades and investigate two further popular FX investment strategies, namely FX momentum and FX value. The most prominent strategy is arguably the carry trade, which is the trading strategy derived from the "forward premium puzzle" (Fama, 1984) and consists of long positions in high interest rate currencies funded by borrowing in low interest rate currencies. If the interest differential is not offset by corresponding exchange rate movements (i.e. if uncovered interest rate parity, UIP, does not hold), there are considerable gains to be made from this form of currency speculation. Carry trades have shown to be highly profitable (see, e.g. Lustig and Verdelhan, 2007) and are widely used among professional currency fund managers (Pojarliev and Levich, 2008). The remaining two strategies we study (FX momentum, and FX value) have also shown to be profitable as documented in the recent work by Ang and Chen (2010), Asness, Moskowitz, and Pedersen (2012), Burnside, Eichenbaum, and Rebelo (2011) or Menkhoff, Sarno, Schmeling, and Schrimpf (2012b), for instance. As pointed out by Pojarliev and Levich (2008), these additional strategies are also very popular in the asset management industry.[1]

Given the Sharpe ratios of these FX strategies documented in the extant literature as well as their fairly low correlations to traditional asset classes, one straightforward question arises: Does the addition of FX styles to the investment opportunity set improve the risk-return profile of international well-diversified portfolios? There is more to this question than meets the eye. The unhedged return of an international asset is composed of two parts, the core asset return in local currency and the

[1] Just to name a few real-life examples which are available for non-institutional investors: Deutsche Bank Carry ETF, Deutsche Bank Momentum ETF, and Deutsche Bank Valuation ETF (all based on the G10 currencies); Investment products with carry strategies including emerging market currencies are also available from UBS (V24 Carry TR Index).

currency return. Taking the recent evidence on common factors in FX markets seriously (Lustig, Roussanov, and Verdelhan, 2011, Verdelhan, 2011), investors should be able to derive diversification benefits by considering both components of international investing. In fact, this is in line with modern portfolio management practice, which often relies on a two-layer approach (see Pojarliev and Levich, 2012, for a detailed description). Typically, in a first step, a hedging strategy is implemented to remove "unintended" currency exposure in core assets such as bonds or equities. In a second step, a return-seeking overlay is implemented and strategic positions in currency markets are established (e.g. Olma and Siegel, 2004).[2]

While optimal currency hedging (i.e. the first step) has received considerable attention in the academic literature so far, e.g. most recently in the work by Campbell, de Medeiros, and Viceira (2010), there are hardly any academic studies about the second step of modern currency management, that is, strategic currency investing. This paper aims at providing a better understanding of the most popular FX investment strategies and their joint stochastic properties with global bonds and equities, and therefore is a first step towards filling this gap. As the benchmark allocation, we consider a well-diversified portfolio of global bonds and stocks. To account for FX risk exposure, we carefully hedge our benchmark assets against exchange rate risk before testing the benefits from FX style investing. The hedging strategies for the benchmark assets – a full hedge, an optimal hedge and a conditional optimal hedge – draw on recent work by Campbell, de Medeiros, and Viceira (2010). This procedure allows us to differentiate between hedging benefits and speculative benefits from FX investing.[3]

Based on this empirical setup we establish three major findings. First, we show that considerable improvements in the portfolio allocation can be achieved by style investing in FX markets. Considering all three baseline FX styles raises the (annualized) Sharpe ratio from 1.25 (benchmark assets, conditional optimal hedge) to 1.62 (FX style augmented portfolio), an increase of about 30%. When the FX investment strategies are constructed from a smaller set of developed market (G10) currencies, we

[2]Several leading asset managers have recently added new forms of FX investment style-related currency management schemes to their product portfolios (which are similar to our set up), stressing the economic importance and relevance of the question we analyze. See, inter alia, UBS: "Currency Management in Equity Portfolios", 2006; Deutsche Bank: "Currency Indices in a Portfolio Context", 2007; J.P. Morgan: "Managing Currency", 2008; BNY Mellon: "New Approaches to Global Currency Management", 2010; PIMCO: "Asset Allocation Rx for Fx: A Risk Factor-Based Approach to Currencies", 2011. Russel Investments: "Conscious Currency - A new approach to understanding currency exposure", 2011. We thank Stephan Siegel who pointed us to this trend.

[3]Our baseline results are obtained for FX style portfolios constructed from 30 liquid and frequently traded currencies. Moreover, we consider a reduced subset of G10 currencies and also account for transaction costs which typically occur due to a re-balancing of currency positions in the FX style portfolios.

still find a significant increase of the Sharpe ratio by 17%. These results hold after correcting for transaction costs (based on quoted bid-ask spreads) that are implied by re-balancing of the FX style portfolios. Furthermore, in an extensive out-of-sample evaluation, we find that the diversification benefits (measured by the increase of the Sharpe ratio) remain significant in this more realistic setting where portfolio decisions are taken in real-time.

Second, we find that considering combinations of all three FX strategies improves the portfolio allocations more than relying on a single FX style in isolation. Correlations between the FX strategies are fairly low. Thus, there are benefits from diversifying within the space of FX investment strategies (a point which is also made by Jorda and Taylor, 2012).[4] In our robustness tests, we also assess the benefits from FX style investing relative to benchmark assets that rely on equity and commodity momentum and value strategies (Asness, Moskowitz, and Pedersen, 2012). We find that FX styles also provide diversification benefits in this setting with benchmark assets that are managed portfolios.

Third, we find that the improvements in portfolio Sharpe ratios from the FX style investments do not imply a worsening of the portfolio downside risk characteristics. This is notable since some of the FX strategies (especially the carry trade, see e.g. Gyntelberg and Remolona, 2007, Brunnermeier, Nagel, and Pedersen, 2009) are prone to occasional large losses, i.e. have negatively skewed return distributions. In our robustness tests, we consider three different additional checks of this issue. We start with an extreme scenario where the carry trade strategy is hedged against extreme downside risk using currency options (as in Jurek, 2009, Burnside, Eichenbaum, Kleshchelski, and Rebelo, 2011). We find that the carry trade still provides some (albeit lower) improvements in the mean-variance space. Next, related to our second major finding, we consider combinations of the three FX strategies. These diversified FX strategies turn out to be much less exposed to negative skewness. Moreover, such combinations of FX styles provide even larger gains as measured by Sharpe ratios. As a final check, we rely on the stochastic dominance criterion, which is based on less restrictive assumptions compared to the traditional mean-variance framework. To that end, we use multivariate second-order and third-order stochastic dominance tests proposed by Post and Versijp (2007). The third-order test allows explicitly to account for investors who dislike negatively skewed return distributions at the portfolio level (i.e.

[4]These results are in line with Eun, Lai, de Roon, and Zhang (2010) who show that equity style diversification is beneficial for global equity portfolios. Eun, Lai, de Roon, and Zhang (2010) find that global style investing in equity markets raises the annualized Sharpe ratio against a U.S. portfolio from 1.14 to 2.39. Notice that they do not account for transaction costs due to portfolio re-balancing in their baseline results.

it takes into account the skewness which remains after FX styles become part of a well-diversified benchmark portfolio). Also the stochastic dominance tests corroborate our baseline results.

Our paper proceeds as follows. We briefly discuss the related literature in Section 2. In Section 3, we provide a detailed description of the FX investment styles in a common framework. Section 4 describes our dataset and shows how our FX style portfolios and benchmark portfolios are constructed. Section 5 presents our major empirical results on the three FX investment strategies and illustrates the gains in international portfolio diversification that can be achieved by FX style investing. Section 6 provides robustness tests and looks at our baseline results from various further angles. Finally, we conclude in Section 7.

2 Related Literature

Ever since the work of Grubel (1968) and Solnik (1974), researchers have become aware of the potential benefits from international diversification. Somewhat surprisingly, many empirical studies were hardly able to identify statistically significant diversification benefits from investments in international developed equity markets.[5] A possible explanation is the ongoing integration of global markets and a thus increasing correlation among international assets (e.g. Eun and Lee, 2010; or Christoffersen, Errunza, Jacobs, and Jin, 2012). By contrast, style-based stock market investing seems to provide distinguishable diversification benefits. Eun, Huang, and Lai (2008) show that benefits are significant for international small cap stocks, and Eun, Lai, de Roon, and Zhang (2010) report similar results for value and momentum strategies.

Most of the diversification studies mentioned above do not rely on returns that are hedged against currency risk. Relatively little attention is devoted to the role of the foreign exchange rate component, which is by construction an unavoidable element of international investments. Some studies, however, carefully consider the exchange rate component in foreign investments, in particular Glen and Jorion (1993) and most recently Campbell, de Medeiros, and Viceira (2010). These studies first and foremost consider the role of individual currency positions and their role for international portfolios. Glen and Jorion (1993) as well as de Roon, Nijman, and Werker (2003) do not find (significant) diversification

[5]To our knowledge, there is not a single study analyzing (non-style-based) international developed stock market returns which finds significant diversification benefits for the tangency portfolio and a recent time period (Britten-Jones, 1999; Errunza, Hogan, and Hung, 1999; Eun, Huang, and Lai, 2008; Kan and Zhou, 2012; Eun, Lai, de Roon, and Zhang, 2010, among others).

benefits of simple currency positions that go beyond fully hedging the currency risk exposure of stock and bond portfolios. Campbell, de Medeiros, and Viceira (2010) find that single currencies are attractive to minimize the risk of global equities. Interestingly, all four studies find further increased portfolio Sharpe ratios for a hedging strategy conditional on the interest rate differential of the domestic country to the foreign country (hence, mimicking some kind of carry trade strategy).

Our study is motivated by these initial findings for simple conditional hedges based on carry in the older literature. It also draws on the results on the profitability of several FX investment strategies documented in more recent papers (e.g. Ang and Chen, 2010; Asness, Moskowitz, and Pedersen, 2012; Burnside, Eichenbaum, and Rebelo, 2011; Lustig, Roussanov, and Verdelhan, 2011; Menkhoff, Sarno, Schmeling, and Schrimpf, 2012b). We go beyond the existing literature by focusing on the diversification benefits due to the speculative component of FX investing as opposed to the gains stemming from the hedging component. Contrary to the older literature, we employ multi-currency investment strategies, which is common practice among market participants nowadays.

3 FX Investment Styles

We study the diversification benefits of three FX investment styles which can be considered the most common strategies by professional currency fund managers (see e.g. Pojarliev and Levich, 2008) and which have received the utmost attention in the recent academic literature. We will describe these investment strategies in the following; they are known as the currency carry trade, the FX momentum, and the FX value strategy.

In our empirical analysis, we use monthly observations and re-balance the style portfolios at the beginning of every month. The end-of-month payoff on a long forward position (also denoted as the "FX excess return" in the following) for currency j is measured as

$$RX_{j;t+1} = \frac{S_{j;t+1} - F_{j;t}}{S_{j;t}}, \tag{1}$$

where $S_{j;t}$ is the spot U.S. dollar (USD) price of one unit of foreign currency j at time $t = 0$, ..., T and $F_{j;t}$ is the one period forward price. Computed this way, the FX return is an excess return since it is a zero net investment consisting of selling USD in the forward market for the foreign currency in

t and buying USD at the future spot rate in $t+1$. All three FX investment strategies generally rely on long-short positions in foreign currencies conditional on a specific signal available one period before. Following Asness, Moskowitz, and Pedersen (2012), we build currency portfolios by weighting them according to their time t specific cross-sectional rank:

$$w_{j;t}^{z(s)} = c_t \left(rank\left(z\left(s\right)_{j;t}\right) - \sum_{j=1}^{J_t} rank\left(z\left(s\right)_{j;t}\right) / J_t \right), \tag{2}$$

$$RZ_{s;t+1} = \sum_{j=1}^{J_t} w_{j;t}^{z(s)} RX_{j;t+1} \qquad s = \{C, M, V\}, \tag{3}$$

where $RZ_{s;t+1}$ denotes the return on the style-based trading strategy and depends on the conditioning variable $z\left(s\right)_t$. J_t denotes the set of currencies that are available for investment in period t. The choice of the signal s determines the particular strategy, e.g. the carry trade (C), FX momentum (M), or FX value (V). The constant c_t is chosen such that the style portfolios are one USD long and one USD short. Using the rank instead of the particular signal mitigates outliers and reduces transaction costs due to portfolio re-balancing (see below). Our rank-based portfolios result in an entirely data-driven weighting scheme for the individual currencies. In contrast, an equally weighted approach as used in much of the extant literature (e.g. Lustig, Roussanov, and Verdelhan, 2011; Menkhoff, Sarno, Schmeling, and Schrimpf, 2012a) would give us an additional degree of freedom by choosing a particular quantile used as a cutoff to determine long-short positions.

Carry trade strategy. The carry trade exploits the well-established empirical failure of uncovered interest rate parity (UIP) known as the "forward premium puzzle" (Fama, 1984). Following the paper by Lustig and Verdelhan (2007), our carry trade strategy goes long (forward) in an equally weighted portfolio of currencies with the largest nominal short-term interest rates (investment currencies), and short (forward) in an equally weighted portfolio of currencies with the smallest nominal short-term interest rates (funding currencies). Thus, our conditioning variable in the carry trade is the interest rate differential between the foreign and the U.S. money market, which we infer from the FX forward premium/discount

$$z(C)_{j;t} = \frac{F_{j;t}}{S_{j;t}} - 1. \tag{4}$$

Carry trade strategies are very profitable, typically have quite attractive risk-return characteristics, are widely used by practitioners and there is evidence that they leave their traces in FX turnover patterns (see Galati, Heath, and McGuire, 2007). Of particular interest in the recent academic literature is whether returns on carry strategies can be explained by a risk premium or whether they should be attributed to the presence of frictions or behavioral biases.[6] In distinction to this literature, we take their returns as given and analyze if there is a (significant) demand for carry trade investments in an internationally diversified portfolio, or in other words, if an investors can improve their investment opportunity set by an investment in a carry trade strategy.

FX momentum strategy. In fact, the carry trade is not the only FX investment style discussed in the academic literature and used by professional currency fund managers. Similar to the well-known momentum returns in stock markets (e.g. Jegadeesh and Titman, 1993), momentum profits have also been documented in FX markets (see e.g. Okunev and White, 2003; Menkhoff, Sarno, Schmeling, and Schrimpf, 2012b). Menkhoff and Taylor (2007) and Pojarliev and Levich (2008) also report some evidence for the high popularity of trend-following FX strategies by professional currency fund managers. Our momentum portfolio goes long in a portfolio of currencies with the highest past cumulative returns (so-called "winners") and short in a portfolio of currencies with the lowest past returns (so-called "losers"). The conditioning variable of the momentum strategy is the cumulative return over the past three months

$$z(M)_{j;t} = \prod_{\tau=0}^{2} (1 + RX_{j;t-\tau}) - 1. \tag{5}$$

Menkhoff, Sarno, Schmeling, and Schrimpf (2012b) show that the momentum signal in currency markets is stronger for more recent past returns. However, they also report that since one-month past returns are more volatile than longer-horizon past returns, transactions costs due to portfolio re-

[6] See, for instance, Lustig and Verdelhan (2007), Bacchetta and van Wincoop (2010), Christiansen, Ranaldo, and Söderlind (2010), Verdelhan (2010), Burnside, Eichenbaum, Kleshchelski, and Rebelo (2011), Burnside, Han, Hirshleifer, and Wang (2011), Lustig, Roussanov, and Verdelhan (2011), Menkhoff, Sarno, Schmeling, and Schrimpf (2012a), for recent contributions.

balancing are larger for the former. To take this trade-off into account, we rely on three-month past returns for our baseline FX momentum strategy. Further variations of the FX momentum strategy are covered in the Online Appendix.

FX value strategy. The basic idea behind the value strategy is to buy currencies considered to trade below a fundamental value and to sell currencies which trade above a fundamental value. One may interpret this strategy as a contrarian or long-term reversal strategy. A widely used measure for fundamental value in currency markets is the real exchange rate defined as

$$Q_{j;t} = \frac{S_{j;t} P_{j;t}}{P_t^*}, \tag{6}$$

where $P_{j;t}$ is the price level of consumer goods in country j in the local currency, and P_t^* the corresponding U.S. price level in USD. If purchasing power parity (PPP) holds between two countries, Equation (6) should be equal to one. Hence, currencies with real exchange rates below (above) unity may be regarded as "undervalued" ("overvalued"). PPP is a rather strong assumption, as an equilibrium real exchange rate can easily deviate from unity (Harrod-Balassa-Samuelson effects). Thus, to avoid the problem of defining an equilibrium real exchange rate, we use a measure of "value" defined as minus one times the cumulative five-year change of the real exchange rate as our conditioning variable

$$z(V)_{j;t} = \left(\frac{Q_{j;t-3}}{\bar{Q}_{j;t-60}} - 1 \right) \times (-1), \tag{7}$$

where $\bar{Q}_{j;t-60}$ is the real exchange rate measured as the average over a period between 5.5 and 4.5 years back in the past.[7] To avoid overlap between the momentum and value conditioning variables, we skip changes of the real exchange rate of the past three months when constructing the FX value measure. Further details on the construction of the value strategy are provided in the Online Appendix.

4 Data and Portfolio Construction

FX data. Bid and ask quotes for spot and one-month forward exchange rates against the USD are from Barclays Bank International (BBI) and WM/Reuters (WMR) and are available via Thomson

[7] The construction of our FX value strategy is motivated by the measure studied by Asness, Moskowitz, and Pedersen (2012). The correlation between our FX value portfolio return and theirs is as large as 0.86.

Reuters Datastream. The FX sample covers the 30 currencies reflecting the lion's share of global market turnover.[8] We also perform tests based on a reduced set of developed market currencies, or "G10 currencies" (currencies of Australia, Canada, Germany, Japan, New Zealand, Norway, Sweden, Switzerland, and the U.K. against the USD). We use CPI data from the IMF's International Financial Statistics (IFS) to calculate real exchange rates for the value strategy.[9] The available currency data span the period from 02/1976 to 12/2011. For the value strategy, we need 5-year changes of the real exchange rate. Thus, the sample period for the FX style returns ranges from 02/1981 to 12/2011. The Online Appendix provides further details on the data and on some conservative data screens which we apply to ensure reliability of our data. Furthermore, we provide a detailed comparison of our FX investment style returns with similar portfolios studied by Burnside, Eichenbaum, Kleshchelski, and Rebelo (2011), Lustig, Roussanov, and Verdelhan (2011), and Asness, Moskowitz, and Pedersen (2012).

Transaction costs. Our style-based investment strategies involve a re-allocation of the positions in the individual currencies in every month according to the signal by the corresponding conditioning variable. Since the monthly re-balancing of the portfolios involves transaction costs, we compute returns both with and without adjusting for bid-ask spreads. Our adjustment procedure is a conservative approach of accounting for transaction costs. The bid-ask spreads in the WMR/BBI database are based on indicative quotes and are thus likely to overstate the true transaction costs of an investor (Lyons, 2001). Moreover, in practice transaction costs may be substantially lower when currency positions are rolled via FX swaps as shown by Gilmore and Hayashi (2011).[10] Details on the transaction cost adjustment are given in the Online Appendix.

[8]This sample of currencies includes Australia, Brazil, Canada, Denmark, Euro, France, Germany, Hungary, Iceland, India, Indonesia, Israel, Italy, Japan, Mexico, New Zealand, Norway, Philippines, Poland, Russia, South Africa, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, Ukraine, and the United Kingdom. According to BIS (2010), our set of currencies covers more than 95 percent of the global FX market turnover in April 2010.

[9]Since the CPI has an arbitrary base year unrelated to PPP, we use the PPP estimate of Heston, Summers, and Aten (2009) for the year 2000 to determine the level of the real exchange rate. The resulting conditioning variable for the value strategy is robust, as we use changes in the real exchange rate.

[10]The literature on international diversification has largely ignored the effects of transaction costs, most likely since no adequate data are available for international stock markets, which are the subject of most studies. An exception, for instance, is the work of de Roon, Nijman, and Werker (2001) who incorporate transaction costs in their study of emerging market equities. They adjust for hypothetical transaction costs and show that for most countries even a small amount of transaction costs is sufficient to keep investors out of the market.

Benchmark assets: Global bonds and stocks. To quantify diversification benefits from style-based FX investing we consider a typical well-diversified international portfolio allocation consisting of global bonds and stocks. The selected countries are the same as those covered by the G10 currencies. In particular, we take the MSCI Total Return (Standard Country) stock market indices for Australia, Canada, Germany, Japan, New Zealand, Norway, Sweden, Switzerland, the United Kingdom, and the United States. These returns are measured in USD and are available for the period from 02/1981 to 12/2011. We obtain these data from Thomsen Reuters Datastream. There are no official bond market indices covering the time period and the cross-section of countries required for our study. Following Campbell, Lo, and MacKinlay (1997) and Campbell, de Medeiros, and Viceira (2010), we use a log yield-return approximation to derive bond market returns. Stock and bond market returns are monthly simple returns in excess of the one-month U.S. Treasury bill rate from Ibbotson (available on the website of Kenneth R. French).[11] Our global bond and equity benchmark assets provide the best possible comparison to the existing literature on international diversification in developed markets.[12]

Dissecting FX speculation from FX hedging. In our analysis we carefully account for the exchange rate risk exposure inherent in the benchmark assets in order to dissect the benefits of hedging and strategic speculative currency positions. The international bond and stock market returns in our benchmark portfolio are exposed to exchange rate risk, i.e. these are unhedged returns $R^{uh}_{j;t}$. However, it is easy to counteract the exchange rate risk using a currency hedging strategy. Indeed, the effects of various hedging strategies are covered by a fairly large literature (e.g., Anderson and Danthine, 1981; Glen and Jorion, 1993, Jorion, 1994 and Campbell, de Medeiros, and Viceira, 2010). Thus, it is interesting to see how various currency hedging strategies affect the benefits from "speculative" FX style investing. The currency hedged return $R^{h}_{j;t}$ can be written as

$$R^{h}_{j;t} = R^{uh}_{j;t} + \widetilde{\boldsymbol{\Psi}}'_{RM}\mathbf{H}_t, \tag{8}$$

where $\widetilde{\boldsymbol{\Psi}}'_{RM}$ is a vector of hedging positions, or risk management demands (Campbell, de Medeiros, and Viceira, 2010), and $\mathbf{H}_t$ is a vector with the returns of the hedges. For the U.S. asset (bond or

[11] In Section 6, we also provide detailed results with alternative benchmark assets covering momentum and value strategies in stocks and commodities (Asness, Moskowitz, and Pedersen, 2012).

[12] Glen and Jorion (1993), de Santis and Gerard (1997), Britten-Jones (1999), de Roon, Nijman, and Werker (2003), Kan and Zhou (2012), Eun, Lai, de Roon, and Zhang (2010), among others, cover similar assets and international markets.

stock), we define $j = 0$ and for the foreign assets $j = 1, ..., 9$. In our baseline specification, the hedges are the G10 currency excess returns ($\mathbf{H}_t = \mathbf{RX}_t$). The vector of G10 currencies follows the same order as the foreign assets, i.e. $\mathbf{RX}_t = [RX_{1,t}, ..., RX_{9,t}]'$.[13]

We consider three types of hedging strategies (full hedge, optimal hedge, and conditionally optimal hedge). A simple (but popular) strategy is the *full hedge*. In this case, the investor hedges the full amount invested in a foreign asset with a counter position in the currency to which the investment is exposed. Accordingly, the vector of risk management demands for the jth foreign asset is simply $\widetilde{\boldsymbol{\Psi}}_{RM} = -\mathbf{1}_j$, which denotes a position in currency j of -1 and zero for all other currencies. Campbell, de Medeiros, and Viceira (2010) study *optimal currency hedges*. They calculate risk management demands such that the variance of U.S. and foreign bonds and stocks is minimized. Here, the vector of risk management demands is minus one times the beta coefficients of a regression of all j currency excess returns ($\mathbf{RX}_t$) on the fully hedged asset (stocks or bonds), which we denote $\widetilde{\boldsymbol{\Psi}}_{RM} = -\mathbf{B}_{\mathbf{RX}}$. Furthermore, Campbell, de Medeiros, and Viceira (2010) propose a *conditional optimal hedge*. This strategy allows for time-varying hedging positions conditional on a specific signal. Campbell, de Medeiros, and Viceira (2010) use foreign interest rate spreads, i.e. this strategy also hedges against carry trade risk. To mimick a conditional optimal hedge, we include the FX investment styles as hedges, i.e. $\mathbf{H}_t = [\mathbf{RX}_t', \mathbf{RZ}_t']'$ where the vector $\mathbf{RZ}_t$ contains the FX investment styles we want to test, and accordingly we denote the risk management demands as $\widetilde{\boldsymbol{\Psi}}_{RM} = [-\mathbf{B}_{\mathbf{RX}}, -\mathbf{B}_{\mathbf{RZ}}]'$.[14]

We can exploit the results based on the optimally hedged benchmark assets to dissect the improvement of the slope of the mean-variance frontier into a speculative component and a hedging component. The intuition is simple. The hedging component is the part of the diversification benefits driven by the non-zero betas (correlations) between the test assets and the benchmark assets. The speculation component is the residual, and will be driven by the return and variance of the test assets. The optimal hedging positions simply orthogonalize the benchmark assets with respect to the hedges by construction.

[13]For example, if $j = 1$ corresponds to the Australian bond (or stock) market return $R^{uh}_{1;t}$, then, $RX_{1,t}$ is the currency excess return of the Australian dollar against the USD.

[14]Campbell, de Medeiros, and Viceira (2010) propose two ways to implement a conditional currency hedge. First, in the main paper, they allow the single currency risk management demands ($-\mathbf{B}_{\mathbf{RX}}$) to be time-varying conditional on foreign interest rate spreads. Second, in the online appendix, they include the carry trade as a hedge together with the single currencies and consider constant risk management demands for the expanded set of hedges. Of course, the carry trade portfolio can be thought of as a managed portfolio exploiting information in foreign interest rate spreads (Cochrane, 2005, Chapter 8). Campbell, de Medeiros, and Viceira (2010) find that the second approach provides very similar - often even slightly better - hedging results.

Thus, when the benchmark assets are orthogonalized with respect to the test assets we are interested in, as is the case for the conditional optimal hedge, any improvement of the Sharpe ratio must be driven solely by the speculative component. In other words, the results we report for optimal conditional hedged benchmark assets allow to make a clear cut between the currency hedging benefits documented by Campbell, de Medeiros, and Viceira (2010) and the benefits from speculative style investing we are interested in. The Online Appendix covers further analytical details on the distinction between the speculation and the hedging component.

5 Empirical Results

5.1 Risk and Return Characteristics

Table 1 reports the annualized risk and return characteristics of our benchmark assets.[15] Global stocks deliver larger annualized average excess returns than bonds, 6.3% compared to 4.8% (unhedged). However, in our sample, the global bonds generate higher reward-per-risk measured by the Sharpe ratio, reflecting an extraordinarily good performance of bond markets over the past decades compared to the longer history.[16] The right-hand side of the table reports characteristics for fully hedged global assets. We find considerably smaller standard deviations for hedged global bonds and stocks compared to their unhedged counterparts.

The Online Appendix also provides results on the effects of the optimal and the conditionally optimal hedges. In line with Campbell, de Medeiros, and Viceira (2010), we find that the full hedge is risk minimizing for global bonds. For global stocks, there are significant additional benefits from an optimal hedge (using single currency positions). Finally, the conditional optimal hedge (including hedging positions in FX styles) generally does not lead to further significant improvements in the allocation for global bonds and stocks.

- INSERT TABLE 1 HERE -

Below the statistics for the benchmark assets we report the risk and return characteristics for the

[15] In most of the empirical part, we consider individual global bond and stock market returns. To conserve space, the descriptive statistics in Table 1 are based on portfolios of global bonds and global stocks (GDP at PPP weights) rather than of individual country returns. The characteristics of the individual country returns are reported in the Online Appendix.

[16] The macroeconomic moderation and disinflation starting in the mid-1980s and a reduction in required risk premiums likely contributed to the extraordinary bond market performance (see Palazzo and Nobili (2010), for a discussion).

three FX investment style portfolios: The carry trade, FX momentum, and FX value. These currency strategies are either based on up to 30 currencies ("all currencies") or a sub-set of developed market currencies ("G10 currencies"). Based on all currencies and before taking into account transaction costs, they provide annualized average returns of 6.2%, 5.3%, and 4.2% respectively for the carry trade, FX momentum, and FX value. Our transaction cost adjustment takes into account portfolio re-balancing using bid and ask quotes. Thus, a more volatile signal will lead to more transactions and will finally result in higher transaction costs. We find that the return of the carry trade after taking into account transaction costs is 5.7%, which represents a loss in the average return of about 8%. Transaction costs for the FX value strategy are of similar magnitude, leading to a transaction cost adjusted average return of 3.8%. The FX momentum signal is considerably more volatile. Transaction costs eat up as much as 29%, reducing the adjusted return to 3.8%.

Restricting the FX investment universe to the G10 currencies leads to less diversified style portfolios (by construction) and hence larger standard deviations. In terms of average returns, the carry trade and FX value portfolios constructed from the G10 currencies are fairly similar in magnitude. The investment restriction, however, has a large negative effect on the average returns of FX momentum.[17] In addition, transaction costs are now as large as 40% and imply average returns after transaction costs of merely 1.9%. Figure 1 illustrates how the cumulative returns of the three FX styles evolve over time and how the returns are affected by transaction costs and restrictions of the investment universe to the G10 currencies.

- INSERT FIGURE 1 HERE -

In terms of Sharpe ratios, the FX investment styles seem to be attractive compared to global bonds and global stocks, even after accounting for transaction costs. An important observation in the table is that the return correlations of the FX portfolios and global bonds and stocks are not only fairly low, but the FX style portfolios are also barely correlated among themselves. Thus, strategy diversification should be beneficial in terms of mean and variance. Furthermore, it is well known that the carry trade is exposed to negative skewness, similar in magnitude to global stock markets (e.g. Gyntelberg and Remolona (2007), Brunnermeier, Nagel, and Pedersen (2009)). By contrast, returns to the FX

[17] This finding is in line with Menkhoff, Sarno, Schmeling, and Schrimpf (2012b) who show that momentum returns based on advanced economy currencies have considerably fallen over time and are no longer significant after transaction costs in recent data.

momentum strategy exhibit a small positive skewness, and the skewness of the FX value strategy is considerably smaller in absolute terms. It therefore seems reasonable that combinations of FX style investments may also improve portfolio characteristics in terms of higher moments. We will elaborate on this point later in more depth (Section 6).

5.2 Mean-Variance Efficiency Tests

Methods. Our major interest is whether adding FX styles to an internationally diversified portfolio improves the mean-variance frontier and may thus be beneficial from an investor's perspective. With the ability to borrow and invest in a risk-free asset, a test of mean-variance efficiency comes down to a test of a shift of the tangency portfolio, or in other words, to testing if the two mean-variance frontiers intersect at the point with the maximum Sharpe ratio. Following Glen and Jorion (1993), Harvey (1995), Eun, Huang, and Lai (2008), and Eun, Lai, de Roon, and Zhang (2010) among others, we use frontier intersection tests to analyze if FX investment styles *significantly* shift the investment opportunity set of a global bond and equity portfolio. We estimate the following pricing model:

$$RZ_{n;t} = \alpha_n + \mathbf{R}_t'\boldsymbol{\beta}_n + \varepsilon_{n;t}, \quad t = 1, ..., T, \tag{9}$$

where $RZ_{n;t}$ is the return of $n = 1, ..., N$ test asset excess returns (FX styles), and $\mathbf{R}_t$ is a $K \times 1$ vector of benchmark asset excess returns (global bonds and global stocks). The null hypothesis of intersection is equivalent to the hypothesis that the N intercepts α_n are not significantly different from zero ($H_0 : \boldsymbol{\alpha} = \mathbf{0}_N$).[18] We report an asymptotic Wald test, $W \sim \chi^2_N$, which is robust against heteroscedasticity and autocorrelation (HAC). We use the Newey and West (1987) kernel and the automatic lag length selection procedure proposed by Andrews (1991).

Bekaert and Urias (1996) propose an alternative to the regression-based mean-variance efficiency tests, which exploits the duality between Hansen and Jagannathan (1991) bounds and mean-variance frontiers. We consider the general asset pricing restriction for the $N + K$ asset excess returns, $\widetilde{\mathbf{R}}_t = [\mathbf{RZ}_t', \mathbf{R}_t']'$:

$$E\left(\widetilde{\mathbf{R}}_t m_t\right) = \mathbf{0}_{N+K}, \tag{10}$$

[18]See Huberman and Kandel (1987), Gibbons, Ross, and Shanken (1989) and Jobson and Korkie (1989).

where m_t is the projection of a stochastic discount factor (SDF) with mean $v = E(m_t)$ onto the demeaned $N + K$ asset returns

$$m_t = v + \left[\widetilde{\mathbf{R}}_t - E\left(\widetilde{\mathbf{R}}_t\right)\right]'\mathbf{b}. \tag{11}$$

The SDF given by Equation (11) prices the $N + K$ asset returns correctly by construction. We can write the vector of SDF coefficients as $\mathbf{b} = [\mathbf{b}_N, \mathbf{b}_K]'$. Bekaert and Urias (1996) show that mean-variance efficiency of the K benchmark assets is implied by the N restrictions $\mathbf{b}_N = \mathbf{0}_N$. Put differently, only the benchmark assets are necessary to price the augmented set of $N + K$ assets. This estimation problem can be cast in a typical Generalized Methods of Moments (GMM) framework. We set $v = 1$, which corresponds to testing intersection at the tangency portfolio in the mean-variance space, and report an HAC-robust asymptotic GMM Wald test, $SDF \sim \chi^2_N$.[19]

Results. We consider whether style-based FX investments provide diversification gains relative to ten global bond markets and ten global stock markets serving as the benchmark (K=20). We test each of the three FX styles, namely, the carry trade, FX momentum, and FX value, separately against the benchmark assets (N=1) and we test all three FX styles together against the benchmark assets (N=3). Before testing for mean-variance efficiency, we apply three different hedging schemes to thoroughly account for the exchange risk exposure inherent in the benchmark assets. The hedging strategies follow previous work by Campbell, de Medeiros, and Viceira (2010).[20] First, we implement a simple full hedge to the benchmark. Second, we add a risk minimizing optimal hedge using single G10 currency positions. And finally, we apply a risk minimizing conditional optimal hedge using single G10 currency positions as well as hedging positions in the FX style for which we test mean-variance efficiency.

Overall, we find economically large and statistically significant diversification benefits for all three FX investment styles. In Panel A of Table 2, for the carry trade based on all available currencies, we find a highly significant increase of the annualized Sharpe ratio from 1.17 to 1.47 against the fully hedged

[19]Kan and Zhou (2012) present some evidence on the power and size of the SDF-Wald test and perform a comparison to the regression-based approach. They find no important differences between the asymptotic test statistics when returns follow a multivariate normal distribution. However, their simulation study shows that the regression-based version is favorable to the SDF-based test when returns follow a multivariate Student-t distribution.

[20]We find that the effects of the different hedging schemes in our sample are quite similar to the results reported by Campbell, de Medeiros, and Viceira (2010). Thus, we report details on our estimated risk management demands ($\widetilde{\boldsymbol{\Psi}}_{RM}$) and further tests of the economic significance of the hedging strategies in the Online Appendix.

benchmark. For the FX momentum and the FX value strategies, the increase of the Sharpe ratio is from 1.17 to 1.27. Finally, adding all three FX styles to the investment universe increases the Sharpe ratio further to 1.61, i.e. there are considerable gains in terms of the maximum achievable Sharpe ratio. From Table 2, we can also infer the effects from the optimal hedge and the conditional optimal hedge of the benchmark assets on the diversification benefits from FX style investing. The optimal hedge of the benchmark assets minimizes the risk of each individual bond and stock market investment by hedge positions in the G10 currencies. The maximum attainable Sharpe ratio of the optimal hedged benchmark assets is 1.20. We find that adding all three FX styles to the optimal hedged benchmark assets, the Sharpe ratio rises further to 1.61, which is a statistically significant increase according to the results from the intersection tests.

- INSERT TABLE 2 HERE -

The conditional optimal hedge also incorporates a risk minimizing position in the particular FX style for which we test mean-variance efficiency. Hence, the Sharpe ratio of the benchmark depends on the specific test asset in this case. Investors using the conditional optimal hedge increase the Sharpe ratio of the benchmark portfolio if they hedge against the carry risk (1.27), FX momentum risk (1.21), and the risk of all three FX styles (1.25). The Sharpe ratio of the benchmark portfolio hedged against FX value risk, however, is slightly decreased (1.17) compared to the simple optimal hedge (1.20). Now, what happens to the allocation if speculative FX style positions are added to the portfolio of the conditionally hedged benchmark assets? Since the benchmark is hedged against FX style risk in these specifications as discussed above, the reported diversification benefits reflect the pure speculative component of FX style investing.[21] The corresponding Sharpe ratios are reported in the right column of Table 2. Adding the FX styles to the asset allocation results in marked improvements in the maximum Sharpe ratios relative to the case of the conditionally optimally hedged benchmark assets. For example, when all three FX styles are considered, the Sharpe ratio is increased to 1.62, an increase of 30% relative to the conditionally hedged benchmark. The diversification benefits that derive from the FX style portfolios are economically large and highly significant. Thus, the benefits

[21]Note that single currency positions are only included for hedging, but not for speculation. If we also allow for speculation, the maximum Sharpe ratio is identical for all hedging schemes by construction and only the changes of the Sharpe ratios differ. The Online Appendix provides results for including speculation benefits from single currencies in the benchmark. The conclusions on the diversification gains from the FX style investments are unaltered.

from the FX styles due to the speculation component are also significant when carefully accounting for the hedging component.

Panel B of Table 2 presents results for when the FX investments are restricted to the G10 currencies. For the carry trade and the FX value strategy, the results are qualitatively similar to the "all currencies" case. Increases in Sharpe ratios are economically large, although they are somewhat lower compared to Panel A. The most notable difference is for FX momentum. Adding the FX momentum strategy which only invests in G10 currencies does not provide significant diversification benefits. This result reflects the facts, documented by Menkhoff, Sarno, Schmeling, and Schrimpf (2012b), that momentum strategies do not perform well for developed market currencies, and that transaction costs due to portfolio re-balancing are large compared to the carry trade.[22] Finally, when we jointly test all three FX styles restricted to the G10 currencies, we can reject equivalence of the Sharpe ratios at the 1% level for the regression-based test and at the 5% level for the SDF-based test. This finding of an improvement in the portfolio allocation holds for all three hedging schemes considered.

Further descriptive statistics of the resulting portfolio characteristics are presented in Table 3 (Panel A). The table also provides the positions (Panel B) of the benchmark allocations and for the case in which the three FX styles are added to the investment universe. Besides the notable effects on the Sharpe ratio, it is notable that adding all three FX styles results in rather weakly skewed return distributions, ranging from -0.07 (all currencies) to -0.08 (G10 currencies).

The benchmark portfolio positions reported in Panel B indicate that global bonds receive a dominant share in all allocations.[23] When the three FX styles are added to the conditional optimal hedged benchmark assets, the optimal positions for the test assets vary from 7% (FX momentum, based on G10 currencies) to 20% (carry trade, based on all currencies). By construction, these weights reflect the pure speculative positions for the three FX styles. How do these positions compare to the FX style hedging positions for our optimized portfolio? We show in the Online Appendix that the hedging positions in the three FX styles can be calculated analytically as $\widetilde{\boldsymbol{\Psi}}_{RZ;RM} \times \mathbf{w}_R$, where $\widetilde{\boldsymbol{\Psi}}_{RZ;RM}$ is the matrix of risk management demands for the three FX styles, and $\mathbf{w}_R$ is the vector of optimal portfolio

[22]In the Online Appendix, we repeat the tests before applying our transaction costs adjustment. These results represent an upper bound of diversification benefits. Here, we find significant benefits also for FX momentum at the 5% level for all three hedging schemes. Thus, the momentum signal in currency markets is not too weak, rather, transaction costs eat up a large proportion of the profits.

[23]To conserve space, the table reports only the sum of the positions of the global bond and equity markets.

weights for global bonds and global stocks. These hedging positions are -4% for the carry trade, -2% for FX momentum, and +2% for FX value (FX styles based on all currencies). These risk-minimizing hedging positions are an order of magnitude lower than the speculative positions.

- INSERT TABLE 3 HERE -

5.3 Out-of-Sample Results

Methods. All of the previous mean-variance efficiency tests are based on in-sample estimation results, that is, the optimal positions in each asset are only determined ex post. A far more realistic assessment is to mimick investment decisions in real-time. In this section, we therefore determine asset allocations ex ante and re-examine our previous results. Similar to DeMiguel, Garlappi, and Uppal (2009), we use optimized as well as naive portfolio formation rules. The naive portfolio formation rule allocates an equal fraction to the three "asset classes", global bonds, global stocks, and FX investment styles. The portfolio of global bonds is a weighted average (GDP at PPP) of the bond returns of the individual markets (as in Table 1). The same applies to the global equity portfolio. The set of test assets is either a specific FX style portfolio or an equally weighted portfolio of all three FX styles. The optimized portfolio formation rule is a mean-variance tangency portfolio where we impose short-sales constraints on all assets. In a rolling sample approach, we take the first 120 observations of our sample to calculate portfolio positions and compute the corresponding portfolio return for the following period. Next, we move the rolling window one period forward and repeat the previous steps. This results in a time series of 251 out-of-sample portfolio returns. We first follow this procedure for the benchmark assets and then apply it to the augmented set of assets including the FX styles.[24] We use the same rolling window approach to apply the optimal hedge and the conditional optimal hedge in our out-of-sample setting.

We notice that we do not intend to compare different portfolio formation rules with each other or even to recommend one of them, as each has its specific drawbacks and difficulties.[25] Rather, for a given portfolio formation rule we focus on the comparison (i.e. the change in the Sharpe ratio) between the portfolio containing the (hedged) benchmark assets and the portfolio containing the augmented asset

[24]The Online Appendix provides results for further portfolio rules (see, e.g. DeMiguel, Garlappi, and Uppal, 2009).

[25]DeMiguel, Garlappi, and Uppal (2009) evaluate the out-of-sample performance of the mean-variance model and the naive 1/N (equal weights) rule across several data sets. Overall, they do not find consistently better results from optimal portfolio formation rules compared to a simple 1/N rule.

menu. To conduct statistical inference, we apply the delta method to calculate HAC-robust t-values for the change in the Sharpe ratio, as proposed by Ledoit and Wolf (2008).

Results for the Hedging Strategies. First, we present results for the out-of-sample economic significance of the benefits from the various currency hedging strategies. These results are interesting since Campbell, de Medeiros, and Viceira (2010) only provide results for the in-sample performance of the different hedging schemes. Table 4 shows that the full hedge leads to significant improvements for all bond markets and most of the stock markets. We also find that, for global bonds, the optimal hedge is actually counterproductive. Our out-of-sample tests indicate a deterioration of the risk characteristics compared to the full hedge. For global stocks, the optimal hedge tends to achieve better results than the full hedge in most cases. However, the gains are only statistically significant (5% level) for four out of the eleven equity markets. Finally, the conditional optimal hedge generally does not perform very well out of sample compared to the other hedging strategies. Only for three out of the 22 assets does the conditional optimal hedge provide some benefits against the optimal hedge in the out-of-sample analysis, and these cases are not statistically significant. In sum, the full hedge emerges as a sound alternative to more sophisticated hedging schemes in our out-of-sample setting, coming close to optimal even for global equities.

- INSERT TABLE 4 HERE -

Results for the FX Styles. We now proceed to the quantitative out-of-sample (OOS) analysis of the FX styles. Do the diversification benefits of the FX strategies, documented via in-sample tests (in Table 2), also show up in a more realistic out-of-sample setting? In Panel A of Table 5 we compare the OOS Sharpe ratios of naive asset allocations, without and with FX investment styles based on all currencies. When we fully hedge the benchmark assets, the annualized Sharpe ratio of the benchmark is 0.63. The Sharpe ratio increases further to 0.88, 0.83, and 0.84, if the asset menu is augmented by the carry trade, FX momentum, or FX value strategies. Once again, we find additional benefits if we add all three FX styles jointly to the investment universe. The Sharpe ratio is as large as 0.91 in this specification, which represents an improvement of about 30% relative to the fully hedged benchmark. These improvements are statistically significant as can be inferred from the t-values. Results based on other hedging strategies for the benchmark (optimal and conditional optimal) speak the same language.

Since the optimal and the conditional optimal hedge tend to perform somewhat worse than the full hedge out-of-sample, the relative improvements from adding the FX styles to the allocation are even somewhat larger (compared to the case of the fully hedged benchmark).

Panel B of Table 5 provides results for the mean-variance optimized portfolio formation rule. Overall, the Sharpe ratios of the portfolios formed by the optimized rule exceed those of the naive portfolios. The diversification benefits from including the FX investment styles, measured by the changes of the Sharpe ratios, are large and highly significant in almost all cases. The main exception is momentum, where the results are only borderline significant.

- INSERT TABLE 5 HERE -

Table 6 reports results for FX styles restricted to the G10 currencies. The changes in Sharpe ratios tend to be smaller in magnitude in all specifications. There are also several cases where adding a single FX investment style portfolio does not result in a significant improvement in the portfolio allocation. When we test for the benefits from adding all three FX styles jointly, however, we can reject equivalence of the Sharpe ratios at the 5% level. This holds for all three hedging schemes and the naive as well as the optimized portfolio formation rule.

- INSERT TABLE 6 HERE -

Finally, Table 7 shows the portfolio characteristics (Panel A) and average positions (Panel B) for the out-of-sample allocations.[26] Similar to the in-sample case, these results suggest that the improvements in portfolio characteristics go beyond the first two moments. Adding all three FX styles to a traditional asset portfolio also yields better downside risk characteristics as measured by the skewness, the 5% Value at Risk, and the 5% Expected Shortfall. The average positions for the mean-variance optimized portfolios are similar to those reported earlier.

- INSERT TABLE 7 HERE -

5.4 Summary of Main Results

Overall, we find evidence of quantitatively large and significant diversification benefits for almost all of the three FX styles. The results generally hold when the FX styles are based on all currencies or based

[26]To save space, we report results only for the full hedge and the conditional optimal hedge. Results for the optimal hedge can be provided by the authors upon request.

on G10 currencies, and when the benchmark assets are fully hedged, optimally hedged, or conditionally optimally hedged. The most notable exception is FX momentum, which only provides diversification benefits if investments in emerging market currencies are available to the investor.

The diversification benefits from FX style investing also show up in an out-of-sample evaluation mimicking investor behavior in real-time. Not surprisingly, the levels of Sharpe ratios are lower out-of-sample, but also more realistic. Importantly, the differences in Sharpe ratios between the benchmark allocations and the allocations including FX styles are still economically large and in most specifications statistically significant. Interestingly, the best results are found for a combination of all three FX investment styles. Figure 2 summarizes our baseline results and documents how a portfolio of global bonds and equities can be improved (measured by the increase of the Sharpe ratio in %) by employing all three FX trading strategies. Based on these major findings, we explore our baseline results from several other angles in the following section.

- INSERT FIGURE 2 HERE -

6 Further Results

6.1 Value and Momentum Everywhere

To further assess the diversification potential of FX investment strategies, we thoroughly tested for the robustness of the results with respect to changes in the set of benchmark assets. Our baseline results (reported in Tables 2) were based on buy and hold positions in the benchmark assets. Now, we consider a set of popular managed portfolios, namely value and momentum portfolios for other asset classes.[27]

We collect the value and momentum "everywhere" portfolios of Asness, Moskowitz, and Pedersen (2012) to check whether FX investment styles provide benefits that go beyond those of value and momentum strategies in other asset classes. We choose their rank-based portfolios which are constructed in a similar way as our FX styles. The benchmark consists of portfolios of global stocks and global bonds, and value and momentum portfolios for U.S., U.K., European, and Japanese equities, country

[27] Fama and French (1998) and Rouwenhorst (1998) document value and momentum premia in international stock markets, and Eun, Lai, de Roon, and Zhang (2010) find large diversification benefits for international style-based equity investing. Value or momentum strategies are also found profitable for country stock market indices, Asness, Liew, and Stevens (2000) and Bhojraj and Swaminathan (2006), and for commodities, Gorton, Hayashi, and Rouwenhorst (2012).

stock market indices, and commodities (K=2+2×6).[28] The sample for all assets covers the period from 07/1981 to 06/2010.

Table 8 provides the results for the mean-variance efficiency tests. We find that the FX investment strategies also yield diversification benefits in this setting where the benchmark assets are managed portfolios. For example, if the benchmark assets are optimally hedged, the Sharpe ratio increases from 2.01 to 2.28 (2.12, for G10 currencies) if we add all three FX style portfolios. This change in return per unit of risk is significant at the 1% level for the FX styles based on all currencies. For the FX styles restricted to G10 currencies, however, only the regression-based test indicates significance at the 10% level. Note, however, that unlike our FX style portfolios, Asness, Moskowitz, and Pedersen (2012) do not account for transaction costs due to portfolio re-balancing.[29] The Online Appendix provides additional results for FX investment styles without taking transaction costs into account, since these test assets are more in line with the benchmark assets. We find larger increases of Sharpe ratios and considerably lower p-values for the tests of mean-variance efficiency. For example, all three FX styles based on G10 currencies increase the Sharpe ratio to 2.14 which is significant at the 5% level according to the regression-based test. Thus, these results on the diversification benefits of FX investment strategies can be considered to be conservative.[30]

- INSERT TABLE 8 HERE -

6.2 Accounting for Skewed Returns

It is well known that some of the FX investment strategies, especially the carry trade, are prone to occasional large losses, that is, the return distribution is negatively skewed (see e.g. Gyntelberg and Remolona, 2007; Brunnermeier, Nagel, and Pedersen, 2009). The standard mean-variance framework ignores this characteristic. In the following, we consider three approaches to account for negative

[28] Descriptive statistics for these alternative benchmark assets are provided in the Online Appendix. The European value and momentum portfolios and the country indices portfolios are exposed to unknown long-short positions in multiple currencies. Thus, it is not feasible to apply the full hedge to all benchmark assets.

[29] Sadka and Korajczyk (2004) show that equity momentum returns are substantially lower when realistic transaction cost adjustments are considered.

[30] Besides transaction costs, there is another reason why our results for the benefits of FX styles are conservative. Long-short portfolios are easy to build in FX forward markets but more difficult to implement in equity markets. However, Eun, Lai, de Roon, and Zhang (2010) report that the achievable Sharpe ratio of the long only leg of global equity styles is considerably smaller. They find that after including short-sales constraints in global equity markets, the maximum Sharpe ratio of global equity styles (i.e. our benchmark here) is reduced by approximately two thirds.

skewness. The first two approaches change the construction of the FX investment portfolios to reduce the negative skewness. The third approach considers an alternative test methodology which explicitly accounts for skewed return distributions.

Options. We first study a modified carry trade strategy where the downside risk is insured using currency options as in Jurek (2009) and Burnside, Eichenbaum, Kleshchelski, and Rebelo (2011). For every long position, an options-based hedging portfolio buys an equal amount of put options such that the investor is compensated for large losses. Similarly, for every short position, an options-based hedging portfolio buys an equal amount of call options. This hedge for downside risk is rather extreme. By construction, given a specific threshold, the investor insures all of the downside risk of the carry trade. We obtain options data from J.P. Morgan for our set of G10 currencies for a limited sample period from 07/1997 to 12/2011. Further details on these data and the construction of the options-based hedge are provided in the Online Appendix to this paper.

Panel A of Table 9 reports the characteristics of the carry trade (based on G10 currencies) with and without options-based downside risk insurance. By construction, the skewness of carry returns is much reduced (in absolute terms) to -0.11 (+0.07) in case of the 10 delta (25 delta) hedge. Burnside, Eichenbaum, Kleshchelski, and Rebelo (2011) report that the costs of these hedges are low in terms of Sharpe ratios, in particular compared to a similar strategy in stock markets. In line with their results, we find that the Sharpe ratio of the carry trade 10 delta (25 delta) hedge is still as large as 0.47 (0.40) compared to 0.55 for the case without downside risk insurance.

Panel B of Table 9 provides tests for mean-variance efficiency for the options-hedged carry strategies. The benchmark assets are global bonds and equities as in our baseline results. Adding the baseline carry trade increases the Sharpe ratio for the fully hedged benchmark assets from 1.55 to 1.66 for this shorter subsample. This increase is significant at the 5% level for both tests. The increase in the Sharpe ratio is 1.62 if the carry trade is hedged using 10 delta options ("far out-of-the-money"), a significant increase at the 10% level for the regression-based test but not for the SDF-based test. Finally, the increase in the Sharpe ratio is 1.60 if the carry trade is hedged using 25 delta options ("out-of-the-money") and (marginally) no longer significant. The results for the optimally hedged and conditional optimally hedged benchmark assets are similar. Thus, insuring all downside risk inherent in the carry trade with options seems to be costly in that it tends to reduce the benefits of diversification.[31]

- INSERT TABLE 9 HERE -

FX strategy diversification. As another possibility we consider whether exposures to higher moments can be diversified to some extent by using combinations of the three FX strategies. Thus, for a moment, we ignore the further diversification potential from global bonds or global stocks. As a first step, we calculate the model-free moments implied by our options data for each of the G10 currencies, as proposed by Bakshi, Kapadia, and Madan (2003). For each FX investment style, we then compute a weighted average of the model-free implied moments of the different currencies. The individual weights are determined according to our FX style portfolio formation approach. In this way we obtain option-based "ex ante" gauges of FX style risk with respect to volatility, skewness, and kurtosis.

The interpretation of these measures is simple. Our FX style portfolios are one USD long in a basket of currencies, and one USD short in another basket of currencies. Thus, if the option-based measure for a particular moment is positive, the particular FX style has the tendency to be long in currencies which are more exposed to that specific moment, and has the tendency to be short in currencies which are less exposed to the specific moment.

- INSERT FIGURE 3 HERE -

The time-series of the option-based gauges of risk are depicted in Figure 3, yielding some interesting additional insights. In line with the earlier literature, we find that the carry trade investment currencies are negatively exposed to skewness. In contrast, FX value long currencies tend to be positively exposed to skewness. There is no clear pattern for the FX momentum currencies. Importantly, the figure also reports the exposures to higher moments for an equally weighted strategy of all three FX styles. The average currency of a strategy that invests equal amounts in all three FX styles is never highly exposed in one or the other direction. Thus, a strategy diversified across all three FX strategies appears to be fairly neutral with respect to skewness. We find a similar diversification pattern for the option-based measure for volatility and kurtosis.

[31] Note, however, that the return distributions of the benchmark assets also exhibit a fair amount of negative skewness. Hence, to level the playing field these assets ought (in principle) be hedged for downside risk as well. Burnside, Eichenbaum, Kleshchelski, and Rebelo (2011) show that a similar downside hedging strategy for U.S. stocks reduces returns from 6.87% to -4.79% (p.a.). Downside risk protection for U.S. equities is therefore far more costly than for the carry trade.

Panel A of Table 10 reports the return and risk characteristics of a simple equally weighted portfolio of the FX strategies. The FX styles are based on all currencies or the G10 currencies and we can make use of the full sample period from 02/1981 to 12/2011. The first three strategies are equally weighted across two FX styles (Carry trade and FX momentum, Carry trade and FX value, FX momentum and FX value). The fourth strategy is equally weighted across all three FX styles. A strategy which combines all three signals is also studied by Jorda and Taylor (2012).[32] We find that the strategy combining FX momentum and FX value is positively skewed and provides a Sharpe ratio of 0.71 (0.48, when restricting to G10 currencies). The strategy combining all three FX styles shows a small negative skewness of -0.03 (-0.32, G10) and yields a Sharpe ratio of 1.00 (0.67, G10).

Panel B of Table 10 shows mean-variance efficiency tests for the diversified FX strategies. The results are notable, in particular for the strategies with low exposures to negative skewness. For example, combining a carry with an FX momentum strategy results in an increase of the Sharpe ratio from 1.17 to 1.52. Also the combination of all three FX styles provides significant diversification benefits. The Sharpe ratio increases from 1.17 to 1.57, a rise which is highly significant. The results are robust to the different hedging schemes for the benchmark assets, and restrictions of the FX investment universe. Relative to single FX strategies, diversified strategies seem to be especially beneficial for the smaller set of G10 currencies. These findings suggest that strategy diversification potentially offers improvements in the portfolio allocation in the mean-variances sense, while at the same time also helping to avoid the negative skewness associated with (some) single FX strategies.

- INSERT TABLE 10 HERE -

Stochastic dominance tests. As a third approach to account for skewness, we consider a testing method which explicitly accounts for higher moments when testing for improvements in the asset allocation. This framework, which relies on the stochastic dominance criterion, is based on less restrictive assumptions compared to the traditional mean-variance framework and allows to take skewness-loving preferences of investors into account. In particular, a portfolio is second-order stochastic dominance (SSD) efficient if it is optimal for a non-satiable and risk-averse investor, and it is third-order stochastic dominance (TSD) efficient if it is optimal for a non-satiable, risk-averse and skewness-loving investor

[32] Jorda and Taylor (2012) provide evidence that FX trading strategies not only based on carry, but augmented by past changes of spot rates and real exchange rates, show less skew and large Sharpe ratios.

(Levy, 2006). Our tests draw on the multivariate SSD and TSD tests as proposed by Post and Versijp (2007). In contrast to the other two approaches discussed before, the multivariate stochastic dominance tests compare the return distributions at the portfolio level, and thus, also account for skewness in the benchmark assets.

To conserve space we report the results of the tests and the methodological details in the Online Appendix of the paper. Overall, our findings on stochastic dominance tests imply that also investors who dislike negatively skewed return distributions would prefer to augment global bond and global stock portfolios with FX styles. Table OA.9 in the Online Appendix shows that the TSD pricing errors (i.e., "TSD alphas") are economically large and significant for all three FX styles. The p-value for a test statistic of TSD efficiency of the benchmark assets, which is similar in spirit to the mean-variance efficiency tests, is below 1%. Also tests for the less restrictive SSD efficiency of the benchmark assets indicate significant improvements of FX style investments at the 1% level.

6.3 Market States

We now examine some dynamic features of diversification, in particular if the benefits depend on the state of the market. Using two different measures of market states, we conduct *conditional* tests of our *out-of-sample* portfolio returns. The first market state measure draws on the work by Cooper, Gutierrez, and Hameed (2004). They define UP markets as months following high 36-month returns of the stock market, and DOWN markets as months following low 36-month returns of the stock market. We use GDP-weighted global stocks as our "stock market", and divide our time t observations into three equally large UP, FLAT, and DOWN market state categories conditional on the time $t-1$ past 36-month return of the stock market. The second measure of market states relies on a macroeconomic variable. Portfolio returns are sorted conditional on the previous month's global industrial production growth (year-on-year).[33] We find that both measures result in qualitatively similar but not identical classifications of UP-FLAT-DOWN market states. Figure 4 indicates that we have roughly two UP and three DOWN market state periods in our sample from 02/1991 to 12/2011 including the dot-com boom and bust as well as the recent financial crisis. The state variables also correspond reasonably well to U.S. recession periods as defined by NBER.

[33] We collect industrial production as reported by FRED, St. Louis FED, for the same countries as for the stock market except for Canada, Norway, Switzerland, and U.K., as there are no monthly data available for these countries. The global industrial production measure is simply GDP-weighted for the available countries.

- INSERT FIGURE 4 HERE -

Table 11 shows out-of-sample Sharpe ratios, as described in Table 5, but conditional on the market state. The benchmark portfolio consists of global bonds and equities (fully hedged), and the test portfolio is the benchmark portfolio augmented with the carry trade, FX momentum, FX value, or all three FX investment styles based on all currencies. The augmented portfolios generally show increased Sharpe ratios during all three market states. However, for FX value, the Sharpe ratio decreases during UP market states (statistically insignificant), when we use global industrial production as the conditioning variable.

- INSERT TABLE 11 HERE -

When we focus on the carry trade, there seems to be a hat-shaped pattern in t-values. They are somewhat larger during FLAT market states, and lower during UP and DOWN market states. For FX value, we find the largest t-values during the DOWN market states. There is no obvious pattern for FX momentum. Interestingly, adding all three FX investment styles tends to provide diversification benefits in all three market states. However, we have to note that statistical power should be somewhat smaller in these tests given the small sample size for the market state sub-sample analysis.[34]

7 Conclusion

In the past, the existing literature on international diversification often did not assign a high priority to the treatment of the foreign exchange component of international investing. Prior work that does take the FX component seriously mostly focuses on how to eliminate FX risk using various hedging strategies, or how to minimize the risk in global bond or equity portfolios using positions in foreign currencies (see, e.g. Glen and Jorion, 1993; Campbell, de Medeiros, and Viceira, 2010).

In this paper, we go beyond the benefits from hedging to shed more light on the speculative component of currency investments. We study the implications of FX investment styles – such as carry trades and widely practiced strategies known as FX momentum, and FX value – for optimal portfolio choice. These strategies are known to be profitable when considered in isolation (see, e.g. Ang and Chen, 2010; Asness, Moskowitz, and Pedersen, 2012; Burnside, Eichenbaum, and Rebelo, 2011; Lustig

[34]We have 251 out-of-sample observations, thus resulting in 84 (83) observations for each market state category.

and Verdelhan, 2007; Menkhoff, Sarno, Schmeling, and Schrimpf, 2012b). But do they provide diversification benefits when the investor already has access to a well-diversified global bond and equity portfolio? To answer this question, we study whether investments in these strategies significantly shift the mean-variance frontier when a benchmark allocation consisting of global bonds and stocks is augmented by FX style investments. Importantly, the benchmark assets are thoroughly hedged in order to dissect the diversification benefits into those deriving from hedging FX risk and those stemming from speculative FX positions.

Our results suggest that style-based FX investments generate significant improvements in the asset allocation. These findings hold after taking into account transaction costs and when controlling for the FX risk inherent in the benchmark assets. Importantly, these results are also confirmed in an extensive out-of-sample experiment with different portfolio formation rules mimicking investor decisions in real-time.

References

Anderson, R. W., and J.-P. Danthine (1981): "Cross Hedging," *Journal of Political Economy*, 89, 1182–1192.

Andrews, D. W. K. (1991): "Heteroskedasticity and Autocorrelation Consistent Covariance Matrix Estimation," *Econometrica*, 59, 817–858.

Ang, A., and J. S. Chen (2010): "Yield Curve Predictors of Foreign Exchange Returns," Working Paper.

Asness, C. S., J. M. Liew, and R. L. Stevens (2000): "Parallels Between the Cross-Sectional Predictability of Stock and Country Returns," *Journal of Portfolio Management*, 23, 79–87.

Asness, C. S., T. J. Moskowitz, and L. H. Pedersen (2012): "Value and Momentum Everywhere," *Journal of Finance*, forthcoming.

Bacchetta, P., and E. van Wincoop (2010): "Infrequent Portfolio Decisions: A Solution to the Forward Discount Puzzle," *American Economic Review*, 100, 870–904.

Bakshi, G., N. Kapadia, and D. Madan (2003): "Stock Return Characterisitics, Skew Laws, and the Differential Pricing of Individual Equity Options," *Review of Financial Studies*, 13, 101–143.

Bekaert, G., and M. S. Urias (1996): "Diversification, Integration and Emerging Market Closed-End Funds," *Journal of Finance*, 51, 835–869.

Bhojraj, S., and B. Swaminathan (2006): "Macromomentum: Returns Predictability in International Equity Indices," *The Journal of Business*, 79, 429–451.

BIS (2010): "Triennial Central Bank Survey," *Foreign Exchange and Derivative Market Activitiy in April 2010*, Revised September 2010.

Britten-Jones, M. (1999): "The Sampling Error in Estimates of Mean-Variance Efficient Portfolio Weights," *Journal of Finance*, 54, 655–671.

Brunnermeier, M. K., S. Nagel, and L. H. Pedersen (2009): "Carry Trades and Currency Crashes," *NBER Macroeconomics Annual 2008*, 23, 313–347.

Burnside, C., M. Eichenbaum, and S. Rebelo (2011): “Carry Trade and Momentum in Currency Markets,” *Annual Review of Financial Economics*, 3, 511–535.

Burnside, C. A., M. Eichenbaum, I. Kleshchelski, and S. Rebelo (2011): “Do Peso Problems Explain the Returns to the Carry Trade?,” *Review of Financial Studies*, 24, 853–891.

Burnside, C. A., B. Han, D. Hirshleifer, and T. Y. Wang (2011): “Investor Overconfidence and the Forward Premium Puzzle,” *Review of Economic Studies*, 78, 523–58.

Campbell, J. Y., K. S. de Medeiros, and L. M. Viceira (2010): “Global Currency Hedging,” *Journal of Finance*, 65, 87–121.

Campbell, J. Y., A. Lo, and C. MacKinlay (1997): *The Econometrics of Financial Markets*. Princeton University Press, Princeton.

Christiansen, C., A. Ranaldo, and P. Söderlind (2010): “The Time-Varying Systematic Risk of Carry Trade Strategies,” *Journal of Financial and Quantitative Analysis*, 46, 1107–1125.

Christoffersen, P., V. Errunza, K. Jacobs, and X. Jin (2012): “Is the Potential for International Diversification Disappearing? A Dynamic Copula Approach,” *Review of Financial Studies*, forthcoming.

Cochrane, J. H. (2005): *Asset Pricing (Revised Edition)*. Princeton University Press, NJ.

Cooper, M. J., R. C. J. Gutierrez, and A. Hameed (2004): “Market States and Momentum,” *Journal of Finance*, 59, 1345–1365.

de Roon, F. A., T. E. Nijman, and B. J. Werker (2001): “Testing for Mean-Variance Spanning with Short Sales Constraints and Transaction Costs: The Case of Emerging Markets,” *Journal of Finance*, 56, 721–742.

——— (2003): “Currency Hedging for International Stock Portfolios: The Usefulness of Mean-Variance Analysis,” *Journal of Banking & Finance*, 27, 327–349.

de Santis, G., and B. Gerard (1997): “International Asset Pricing and Portfolio Diversification with Time-Varying Risk,” *Journal of Finance*, 52, 1881–1912.

DeMiguel, V., L. Garlappi, and R. Uppal (2009): "Optimal Versus Naive Diversification: How Inefficient is the 1/N Portfolio Strategy?," *Review of Financial Studies*, 22, 1915–1953.

Errunza, V., K. Hogan, and M.-W. Hung (1999): "Can the Gains from International Diversification be Achieved without Trading Abroad?," *Journal of Finance*, 54, 2075–2107.

Eun, C. S., W. Huang, and S. Lai (2008): "International Diversification with Large- and Small-Cap Stocks," *Journal of Financial and Quantitative Analysis*, 43, 489–523.

Eun, C. S., S. Lai, F. A. de Roon, and Z. Zhang (2010): "International Diversification with Factor Funds," *Management Science*, 56, 1500–1518.

Eun, C. S., and J. Lee (2010): "Mean-Variance Convergence Around the World," *Journal of Banking & Finance*, 34, 856–870.

Fama, E. F. (1984): "Forward and Spot Exchange Rates," *Journal of Monetary Economics*, 14, 319–338.

Fama, E. F., and K. R. French (1998): "Value versus Growth: The International Evidence," *Journal of Finance*, 53, 1975–1999.

Froot, K. A., and R. Thaler (1990): "Anomalies Foreign Exchange," *Journal of Economic Perspectives*, 4(3), 179–192.

Galati, G., A. Heath, and P. McGuire (2007): "Evidence of Carry Trade Activity," *BIS Quarterly Review*, (Sept.), 27–41.

Gibbons, M. R., S. A. Ross, and J. Shanken (1989): "A Test of the Efficiency of a Given Portfolio," *Econometrica*, 57(5), 1121–1152.

Gilmore, S., and F. Hayashi (2011): "Emerging Market Currency Excess Returns," *American Economic Journal: Macroeconomics*, 3, 85–111.

Glen, J., and P. Jorion (1993): "Currency Hedging for International Portfolios," *Journal of Finance*, 48, 1865–1886.

Gorton, G. B., F. Hayashi, and K. G. Rouwenhorst (2012): "The Fundamentals of Commodity Futures Returns," *Review of Finance*, 17, 35–105.

Grubel, H. G. (1968): "Internationally Diversified Portfolios: Welfare Gains and Capital Flows," *American Economic Review*, 58, 1299–1314.

Gyntelberg, J., and E. M. Remolona (2007): "Risk in Carry Trades: A Look at Target Currencies in Asia and the Pacific," *BIS Quarterly Review*, (Dec.), 73–82.

Hansen, L. P., and R. Jagannathan (1991): "Implications of Security Market Data for Models of Dynamic Economies," *Journal of Political Economy*, 99, 225–262.

Harvey, C. R. (1995): "Predictable Risk and Returns in Emerging Markets," *Review of Financial Studies*, 8, 773–816.

Heston, A., R. Summers, and B. Aten (2009): "Penn World Table, Income and Prices at the University of Pennsylvania," Center for International Comparisons of Production, Version 6.3, August.

Huberman, G., and S. Kandel (1987): "Mean-Variance Spanning," *Journal of Finance*, 42, 873–888.

Jegadeesh, N., and S. Titman (1993): "Returns to Buying Winners and Selling Losers: Implications for Stock Market Efficiency," *Journal of Finance*, 48, 65–91.

Jobson, J., and B. Korkie (1989): "A Performance Interpretation of Multivariate Tests of Asset Set Intersection, Spanning, and Mean-Variance Efficiency," *Journal of Financial and Quantitative Analysis*, 24, 185–204.

Jorda, O., and A. M. Taylor (2012): "The Carry Trade and Fundamentals: Nothing to fear but FEER itself," *Journal of International Economics*, 88, 74–90.

Jorion, P. (1994): "Mean/Variance Analysis of Currency Overlays," *Financial Analysts Journal*, May-June 50, 48–56.

Jurek, J. W. (2009): "Crash-neutral Currency Carry Trades," Working Paper.

Kan, R., and G. Zhou (2012): "Tests of Mean-Variance Spanning," *Annals of Economics and Finance*, 13, 145–193.

Ledoit, O., and M. Wolf (2008): "Robust Performance Hypothesis Testing with the Sharpe Ratio," *Journal of Empirical Finance*, 15, 850–859.

Levy, H. (2006): *Stochastic Dominance*. Springer Science Business Media.

Lustig, H., N. Roussanov, and A. Verdelhan (2011): "Common Risk Factors in Currency Markets," *Review of Financial Studies*, 24, 3731–3777.

Lustig, H., and A. Verdelhan (2007): "The Cross Section of Foreign Currency Risk Premia and Consumption Growth Risk," *American Economic Review*, 97, 89–117.

Lyons, R. K. (2001): *The Microstructure Approach to Exchange Rates*. MIT Press, Cambridge.

Menkhoff, L., L. Sarno, M. Schmeling, and A. Schrimpf (2012a): "Carry Trades and Global Foreign Exchange Volatility," *Journal of Finance*, 67, 681–718.

——— (2012b): "Currency Momentum Strategies," *Jounal of Financial Economics*, 106, 660–684.

Menkhoff, L., and M. P. Taylor (2007): "The Obstinate Passion of Foreign Exchange Professionals: Technical Analysis," *Journal of Economic Literature*, 45, 936–972.

Newey, W. K., and K. D. West (1987): "A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix," *Econometrica*, 55(3), 703–708.

Okunev, J., and D. White (2003): "Do Momentum-Based Strategies Still Work in Foreign Currency Markets?," *Journal of Financial and Quantitative Analysis*, 38, 425–447.

Olma, A. R., and L. B. Siegel (2004): "A New Framework for International Investing," *Journal of Portfolio Management*, 30, 55–69.

Palazzo, G., and S. Nobili (2010): "Explaining and Forecasting Bond Risk Premiums," *Financial Analysts Journal*, July-August 66, 1–16.

Pojarliev, M., and R. M. Levich (2008): "Do Professional Currency Managers Beat the Benchmark?," *Financial Analysts Journal*, September-October 64, 18–32.

——— (2012): *Is There Skill or Alpha in Currency Investing? In: The Handbook of Exchange Rates, Jessica James, Ian March and Lucio Sarno (eds.)*. Wiley.

Post, T., and P. Versijp (2007): "Multivariate Tests for Stochastic Dominance Efficiency of a Given Portfolio," *Journal of Financial and Quantitative Analysis*, 42, 489–515.

Rouwenhorst, K. G. (1998): "International Momentum Strategies," *Journal of Finance*, 53, 267–284.

Sadka, R., and R. A. Korajczyk (2004): "Are momentum profits robust to trading costs?," *Journal of Finance*, 59, 1039–1082.

Solnik, B. H. (1974): "Why Not Diversify Internationally Rather Than Domestically?," *Financial Analysts Journal*, July-August 30, 48–54.

Verdelhan, A. (2010): "A Habit-Based Explanation of the Exchange Rate Risk Premium," *Journal of Finance*, 65, 123–146.

——— (2011): "The Share of Systematic Variation in Bilateral Exchange Rates," Working Paper (November).

Table 1: Risk and Return Characteristics of FX Investment Styles

The table reports the mean (in percentage points), standard deviation (Std), skewness (Skew), first order autocorrelation (Ac1), and the Sharpe ratio (SR) of benchmark assets and FX investment styles. The mean is annualized by multiplying by 12, the standard deviation and the Sharpe ratio (SR) are annualized by multiplying by $\sqrt{12}$. FX styles are conditional on time t-1 forward discounts (Carry trade, "C"), the previous 3-month cumulative returns (FX momentum, "M"), and the 5-year change of the real exchange rate (FX value, "V"). The FX investment styles are based on a broad set of up to 30 currencies ("all currencies") or a smaller sub-set of major currencies ("G10 currencies"). The G10 currencies cover the same countries as the bond and stock markets. Results for FX styles are reported before and after taking into account transaction costs. The "ba/loss" gives the reduction in mean returns due to the bid-ask spread adjustment (in %). Statistics for global bonds ("B") and global stocks ("S") are based on a GDP weighted portfolio of ten international markets covering Australia, Canada, Germany, Japan, New Zealand, Norway, Sweden, Switzerland, the U.K, and the U.S. The GDP weights correspond to the countries' share in world GDP at PPP in 1980 (OECD database). All returns are measured as excess returns. Correlations are reported for returns after transaction costs. The sample period is 02/1981 - 12/2011 (371 observations).

	Mean	Std	Skew	Ac1	SR	Mean	Std	Skew	Ac1	SR	ba/loss
	no hedge					full hedge					
U.S. bonds	4.56	7.31	0.50	0.28	0.62						
U.S. stocks	6.56	15.53	-0.60	0.06	0.42						
Global bonds	4.75	7.59	0.25	0.24	0.63	4.21	5.38	0.42	0.34	0.78	
Global stocks	6.34	15.12	-0.75	0.11	0.42	5.81	14.31	-1.03	0.12	0.41	
	FX styles based on all currencies										
	before transaction costs					after transaction costs					
Carry trade	6.18	7.50	-0.63	0.10	0.82	5.67	7.52	-0.63	0.10	0.75	-8.3
FX momentum	5.34	7.68	0.25	-0.09	0.70	3.80	7.76	0.24	-0.08	0.49	-28.9
FX value	4.18	6.69	-0.31	0.09	0.62	3.82	6.69	-0.32	0.09	0.57	-8.6
	FX styles based on G10 currencies										
	before transaction costs					after transaction costs					
Carry trade	5.05	8.76	-0.70	0.03	0.58	4.71	8.78	-0.69	0.03	0.54	-6.88
FX momentum	3.18	8.41	0.13	-0.11	0.38	1.90	8.49	0.12	-0.10	0.22	-40.16
FX value	4.51	8.27	-0.00	0.07	0.54	4.19	8.27	-0.00	0.07	0.51	-7.00

	Correlation (all currencies)					Correlation (G10 currencies)				
	Global		FX styles			Global		FX styles		
	B	S	C	M	V	B	S	C	M	V
Global bonds (B)	1.00					1.00				
Global stocks (S)	0.06	1.00				0.06	1.00			
Carry trade (C)	-0.20	0.27	1.00			-0.19	0.31	1.00		
FX momentum (M)	-0.01	0.00	-0.01	1.00		0.02	-0.01	0.12	1.00	
FX value (V)	-0.02	0.01	0.05	0.09	1.00	-0.02	-0.02	0.05	0.14	1.00

Table 2: Mean-Variance Efficiency Tests for FX Styles

This table reports the results of mean-variance frontier intersection tests for the tangency portfolio of "K" traditional assets (benchmark) when "N" FX investment styles are added to the investment universe as test assets. The K benchmark assets are ten individual bond and stock markets from Australia, Canada, Germany, Japan, New Zealand, Norway, Sweden, Switzerland, U.K., and the U.S. (K=20). Before testing for mean-variance efficiency, we apply three different hedging schemes to the benchmark assets:

$$R^h_{j;t} = R^{uh}_{j;t} + \widetilde{\mathbf{\Psi}}'_{RM}\mathbf{H}_t,$$

where $R^{uh}_{j;t}$ denotes the unhedged benchmark asset return of a bond or stock market of country j and $\mathbf{H}_t$ are the hedges. The full hedge unitarily hedges the country j specific currency risk. As in Campbell, de Medeiros, and Viceira (2010), the optimal hedge minimizes the standard deviation of the benchmark asset returns using all G10 currencies ($\mathbf{H}_{t+1} = \mathbf{RX}_{t+1}$). The conditional optimal hedge includes positions in the single G10 currencies and the FX investment style(s) to be tested ($\mathbf{H}_{t+1} = [\mathbf{RX}'_{t+1}, \mathbf{RZ}'_{t+1}]'$) . Each FX investment style is tested separately (N=1) and all three are tested jointly (N=3) against the benchmark assets. The table reports the p-value of a regression-based test (in column W) and the p-value of a stochastic discount factor based test (column SDF) for mean-variance efficiency. The test statistics are robust against heteroscedasticity and autocorrelation (Newey and West, 1987 kernel and automatic lag length selection according to Andrews, 1991). The Sharpe ratio is reported for the tangency portfolio of all K benchmark assets and when the N test assets are added. These values are annualized by multiplying with $\sqrt{12}$. The FX investment styles are based on a broad set of up to 30 currencies (Panel A) or a smaller sub-set of G10 currencies (Panel B) and are adjusted for transaction costs due to portfolio re-balancing. The sample period is 02/1981 - 12/2011.

Benchmark: Global bonds and global stocks										
	full hedge $\widetilde{\mathbf{\Psi}}_{RM} = -\mathbf{1_j}$			optimal hedge $\widetilde{\mathbf{\Psi}}_{RM} = -\mathbf{B_{RX}}$			conditional optimal $\widetilde{\mathbf{\Psi}}_{RM} = [-\mathbf{B_{RX}}, -\mathbf{B_{RZ}}]'$			
	W	SDF	Sharpe	W	SDF	Sharpe	W	SDF	Sharpe	
	p-value		ratio	p-value		ratio	p-value		ratio	
Panel A: FX styles based on all currencies										
		Bench.:	1.17		Bench.:	1.20			Bench.	+FXS
Carry trade	0.000	0.000	1.47	0.000	0.001	1.46	0.000	0.002	1.27	1.48
FX momentum	0.002	0.004	1.27	0.002	0.003	1.31	0.003	0.005	1.21	1.31
FX value	0.009	0.014	1.27	0.009	0.017	1.31	0.003	0.008	1.17	1.30
All	0.000	0.000	1.61	0.000	0.000	1.61	0.000	0.000	1.25	1.62
Panel B: FX styles based on G10 currencies										
		Bench.:	1.17		Bench.:	1.20			Bench.	+FXS
Carry trade	0.000	0.002	1.34	0.002	0.011	1.33	0.003	0.015	1.24	1.35
FX momentum	0.192	0.182	1.19	0.191	0.168	1.22	0.199	0.178	1.20	1.22
FX value	0.018	0.021	1.26	0.021	0.026	1.29	0.012	0.016	1.18	1.28
All	0.001	0.009	1.42	0.004	0.034	1.40	0.003	0.036	1.21	1.41

Table 3: Portfolio Characteristics and Positions

Panel A displays the mean (in percentage points), standard deviation (Std), skewness (Skew), and the Sharpe ratio of the in-sample optimal portfolios in Table 2. The mean is annualized by multiplying by 12, the standard deviation and the Sharpe ratio (SR) are annualized by multiplying by $\sqrt{12}$. Below the column headers "full hedge", "optimal hedge", and "conditional optimal hedge" we report the properties of the benchmark portfolios of global bonds and global stocks using different hedging schemes. Below the column header "conditional optimal + FXS" we present the characteristics of the conditional optimally hedged portfolio when FX styles ("FXS") are added to the benchmark allocation of conditionally hedged assets. Panel B provides the positions of the benchmark assets and FX styles. The sample period is 02/1981 - 12/2011.

Panel A: Characteristics of optimal portfolios						
	FX styles based on all currencies				G10 currencies	
	full hedge	optimal hedge	cond. opt.	cond. + FXS	cond. opt.	cond. + FXS
Mean	5.42	5.51	6.06	5.37	5.69	5.24
Std	4.65	4.59	4.86	3.32	4.68	3.58
SR	1.17	1.20	1.25	1.62	1.21	1.46
Skew	-0.12	-0.09	-0.08	-0.07	-0.06	-0.08
Panel B: Optimal portfolio positions (max. Sharpe ratio)						
Global bonds (Σ)	0.98	0.99	1.04	0.55	1.00	0.64
Global stocks (Σ)	0.02	0.01	-0.04	-0.02	0.00	0.00
Carry trade	0.00	0.00	0.00	0.20	0.00	0.15
FX momentum	0.00	0.00	0.00	0.12	0.00	0.07
FX value	0.00	0.00	0.00	0.15	0.00	0.14

Table 4: Out-of-Sample Economic Significance of Risk Management Demands

The table shows the standard deviation of global bonds and equities (the benchmark assets) for different hedging schemes in an out-of-sample setting. The Campbell, de Medeiros, and Viceira (2010) risk management demands for the optimal hedge and the conditional optimal hedge are calculated using a 120 months rolling window approach. We use the first 120 observations of our sample to calculate the hedging weights for the hedged benchmark asset return in period 121. Next, we move the rolling window one period forward and repeat the previous step, which results in a time-series of out-of-sample hedged benchmark asset returns. The sample period is 02/1981 - 12/2011. All performance results, also for the no hedge and the full hedge schemes, are based on the sample period 02/1991 - 12/2011.

	Standard deviation % $\times\sqrt{12}$				Tests of significance					
	no hedge	full hedge	opt. hedge	cond. opt.	FH vs. NO		OH vs. FH		OH vs. CO	
	(NO)	(FH)	(OH)	(CO)	F-stat	p-val.	F-stat	p-val.	F-stat	p-val.
					GDP PPP weighted portfolios					
Global bonds	6.74	4.82	4.87	4.91	1.96	0.00	0.98	0.57	0.98	0.56
Global stocks	15.13	14.23	12.42	12.28	1.13	0.17	1.31	0.02	1.02	0.43
					Individual global bond markets					
U.S.		6.45	6.57	6.58			0.96	0.61	1.00	0.51
AU	13.07	6.73	6.85	7.05	3.77	0.00	0.97	0.60	0.94	0.68
CA	9.69	5.85	6.01	6.19	2.74	0.00	0.95	0.66	0.94	0.68
JP	11.65	4.78	4.83	4.88	5.95	0.00	0.98	0.57	0.98	0.56
GE	12.74	5.62	6.08	6.28	5.14	0.00	0.85	0.89	0.94	0.70
NZ	13.45	6.88	7.23	7.48	3.82	0.00	0.90	0.79	0.93	0.71
NO	12.55	7.72	8.04	8.21	2.64	0.00	0.92	0.74	0.96	0.64
SE	13.00	6.51	6.65	6.89	3.99	0.00	0.96	0.63	0.93	0.71
SW	12.80	5.11	5.49	5.62	6.27	0.00	0.87	0.87	0.96	0.64
U.K.	10.72	6.03	6.31	6.45	3.16	0.00	0.91	0.76	0.96	0.63
					Individual global stock markets					
U.S.		15.14	14.05	13.70			1.16	0.12	1.05	0.34
AU	20.97	13.50	12.92	12.90	2.42	0.00	1.09	0.24	1.00	0.49
CA	20.28	15.44	13.16	13.11	1.73	0.00	1.38	0.01	1.01	0.48
JP	23.09	21.44	19.58	19.94	1.16	0.12	1.20	0.08	0.96	0.61
GE	20.35	18.93	18.08	18.47	1.16	0.13	1.10	0.23	0.96	0.63
NZ	22.40	17.01	17.17	17.46	1.74	0.00	0.98	0.56	0.97	0.60
NO	27.19	23.45	20.85	21.28	1.34	0.01	1.27	0.03	0.96	0.63
SE	26.65	24.07	22.62	23.19	1.23	0.05	1.13	0.16	0.95	0.65
SW	17.11	16.01	14.80	15.14	1.14	0.15	1.17	0.11	0.96	0.64
U.K.	16.49	14.50	12.96	13.21	1.29	0.02	1.25	0.04	0.96	0.62

Table 5: Out-of-Sample Sharpe Ratios: All Currencies

The table reports Sharpe ratios for allocations with and without FX investment styles in an out-of-sample setting. The benchmark allocations ("Bench.") are based on global bonds and global stocks (covering Australia, Canada, Germany, Japan, New Zealand, Norway, Sweden, Switzerland, U.K., U.S.). The test assets are FX investment styles adjusted for transaction costs and are based on a broad set of up to 30 currencies. The test portfolio allocations are based on the benchmark assets augmented with one specific FX investment style or augmented with all three FX investment styles ("+FXS"). For the naive portfolio formation rule in Panel A, we allocate 1/2 to global stocks (GDP at PPP weighted), and 1/2 to global bonds (GDP at PPP weighted). For the augmented portfolios, we weight global bonds, global stocks, and FX investment styles 1/3. The optimization portfolio formation rule in Panel B is a mean-variance tangency portfolio with short-selling constraints. We use the first 120 observations of our sample to calculate the portfolio weights for the return in period 121. Next, we move the rolling window one period forward and repeat the previous step, which results in a time-series of out-of-sample returns of one benchmark and one test portfolio. The 120 months rolling window scheme is also used to find out-of-sample risk management demands (optimal hedge / conditional optimal hedge) for the naive as well as for the optimized portfolio formation rule. We report HAC-robust t-statistics for the difference in Sharpe ratios ($\triangle SR$) between the benchmark allocations and the test portfolio allocations in brackets (Newey and West, 1987 kernel with four lags). The sample period is 02/1981 - 12/2011, all portfolio performance results are based on the sample period 02/1991 - 12/2011.

Benchmark: Global bonds and global stocks							
	full hedge $\widetilde{\boldsymbol{\Psi}}_{RM} = -\mathbf{1_j}$		optimal hedge $\widetilde{\boldsymbol{\Psi}}_{RM} = -\mathbf{B_{RX}}$		conditional optimal $\widetilde{\boldsymbol{\Psi}}_{RM} = [-\mathbf{B_{RX}}, -\mathbf{B_{RZ}}]'$		
	Sharpe ratio	$t_{\triangle SR}$	Sharpe ratio	$t_{\triangle SR}$	Sharpe ratio		$t_{\triangle SR}$
Panel A: Naive portfolio formation (1/3 stocks, 1/3 bonds, 1/3 FX styles)							
Bench.	0.63		0.50		Bench.	+FXS	
Carry trade	0.88	[2.17]	0.84	[2.53]	0.44	0.83	[2.71]
FX momentum	0.83	[1.94]	0.71	[1.97]	0.48	0.71	[2.04]
FX value	0.84	[2.20]	0.72	[2.27]	0.46	0.69	[2.31]
All	0.91	[4.52]	0.82	[4.41]	0.45	0.79	[4.51]
Panel B: Mean-variance optimized portfolio formation (without short-sales)							
Bench.	0.76		0.60		Bench.	+FXS	
Carry trade	1.09	[2.44]	0.89	[1.89]	0.67	0.90	[1.44]
FX momentum	0.87	[1.34]	0.74	[1.81]	0.62	0.75	[1.72]
FX value	0.96	[2.01]	0.81	[2.14]	0.59	0.81	[2.36]
All	1.26	[3.48]	1.05	[3.06]	0.64	1.09	[2.71]

Table 6: Out-of-Sample Sharpe Ratios: G10 Currencies

The table reports Sharpe ratios for allocations with and without FX investment styles in an out-of-sample setting. The benchmark allocations ("Bench") are based on global bonds and stocks (covering Australia, Canada, Germany, Japan, New Zealand, Norway, Sweden, Switzerland, U.K., U.S.). The test assets are FX investment styles adjusted for transaction costs and are based on G10 currencies. The test portfolio allocations are based on the benchmark assets augmented with one specific FX investment style or augmented with all three FX investment styles ("+FXS"). For the naive portfolio formation rule in Panel A, we allocate 1/2 to global stocks (GDP at PPP weighted), and 1/2 to global bonds (GDP at PPP weighted). For the augmented portfolios, we weight global bonds, global stocks, and FX investment styles 1/3. The optimization portfolio formation rule in Panel B is a mean-variance tangency portfolio with short-selling constraints. We use the first 120 observations of our sample to calculate the portfolio weights for the return in period 121. Next, we move the rolling window one period forward and repeat the previous step, which results in a time-series of out-of-sample returns of one benchmark and one test portfolio. The 120 months rolling window scheme is also used to find out-of-sample risk management demands (optimal hedge / conditional optimal hedge) for the naive as well as for the optimized portfolio formation rule. We report HAC-robust t-statistics for the difference in Sharpe ratios ($\triangle SR$) between the benchmark allocations and the test portfolio allocations in brackets (Newey and West, 1987 kernel with four lags). The sample period is 02/1981 - 12/2011, all portfolio performance results are based on the sample period 02/1991 - 12/2011.

Benchmark: Global bonds and global stocks							
	full hedge $\widetilde{\boldsymbol{\Psi}}_{RM} = -\mathbf{1_j}$		optimal hedge $\widetilde{\boldsymbol{\Psi}}_{RM} = -\mathbf{B_{RX}}$		conditional optimal $\widetilde{\boldsymbol{\Psi}}_{RM} = [-\mathbf{B_{RX}}, -\mathbf{B_{RZ}}]'$		
	Sharpe ratio	$t_{\triangle SR}$	Sharpe ratio	$t_{\triangle SR}$	Sharpe ratio		$t_{\triangle SR}$
Panel A: Naive portfolio formation (1/3 stocks, 1/3 bonds, 1/3 FX styles)							
Bench.	0.63		0.50		Bench.	+FXS	
Carry trade	0.75	[1.11]	0.73	[1.67]	0.46	0.71	[1.77]
FX momentum	0.67	[0.37]	0.54	[0.36]	0.50	0.54	[0.42]
FX value	0.83	[1.46]	0.69	[1.54]	0.44	0.65	[1.70]
All	0.81	[2.37]	0.72	[2.64]	0.43	0.67	[2.78]
Panel B: Mean-variance optimized portfolio formation (without short-sales)							
Bench.	0.76		0.60		Bench.	+FXS	
Carry trade	0.91	[1.51]	0.77	[1.63]	0.58	0.74	[1.63]
FX momentum	0.78	[0.34]	0.64	[1.08]	0.62	0.65	[0.75]
FX value	0.89	[1.33]	0.72	[1.30]	0.56	0.73	[1.70]
All	1.01	[2.20]	0.86	[2.21]	0.52	0.80	[2.30]

Table 7: Out-of-Sample Portfolio Characteristics and Positions

The table reports portfolio characteristics and average positions in benchmark assets ("Bench") and the three FX investment styles ("+FXS") of the out-of-sample allocations in Table 5. VaR is the Value at Risk. ES is the Expected Shortfall and is based on the historical return distribution. Returns are annualized by multiplying with 12, the standard deviation is annualized by multiplying with $\sqrt{12}$.

Panel A: Characteristics of out-of-sample portfolios; FX styles are based on all currencies								
	Naive portfolios				Mean-variance without short sales			
	full hedge	full + FXS	cond. opt.	cond. + FXS	full opt.	full + FXS	cond. opt.	cond. + FXS
Mean	4.49	4.72	3.02	3.74	3.50	4.14	3.11	3.69
Std	7.17	5.20	6.71	4.74	4.59	3.29	4.86	3.40
SR	0.63	0.91	0.45	0.79	0.76	1.26	0.64	1.08
Skew	-0.66	-0.51	0.57	0.57	-0.38	-0.05	-0.45	-0.27
VaR 5%	39.11	27.81	33.15	22.85	20.51	16.92	23.43	16.56
ES 5%	54.64	37.07	43.85	28.10	32.93	22.11	34.91	24.62
Panel B: Out-of-sample portfolio positions								
Global bonds (Σ)	0.50	0.33	0.50	0.33	0.86	0.52	0.85	0.49
Global stocks (Σ)	0.50	0.33	0.50	0.33	0.14	0.05	0.15	0.09
Carry trade	0.00	0.11	0.00	0.11	0.00	0.19	0.00	0.18
FX momentum	0.00	0.11	0.00	0.11	0.00	0.10	0.00	0.09
FX value	0.00	0.11	0.00	0.11	0.00	0.15	0.00	0.16

Table 8: FX Styles and Value and Momentum "Everywhere"

The table displays mean-variance efficiency tests as described in Table 2, except that the benchmark includes one global bonds portfolio (GDP at PPP weighted), one global stocks portfolio (GDP at PPP weighted), as well as twelve (rank-based) value and momentum portfolios across countries and asset classes provided by Asness, Moskowitz, and Pedersen (2012). These portfolios cover one value and one momentum strategy for the stock markets of the U.S., the U.K., Europe, Japan, country indices, and commodities (K=2+12). The FX styles are based on all currencies in Panel A and they are based on the G10 currencies in Panel B. The FX styles account for transaction costs due to portfolio re-balancing. The benchmark assets by Asness, Moskowitz, and Pedersen (2012) do not account for any transaction costs. The sample period is 07/1981 - 06/2010.

Benchmark: Value and momentum "everywhere" (not adjusted for transaction costs)							
	optimal hedge $\widetilde{\boldsymbol{\Psi}}_{RM} = -\mathbf{B_{RX}}$			conditional optimal $\widetilde{\boldsymbol{\Psi}}_{RM} = [-\mathbf{B_{RX}}, -\mathbf{B_{RZ}}]'$			
	W	SDF	Sharpe	W	SDF	Sharpe	
	p-value		ratio	p-value		ratio	
Panel A: FX styles based on all currencies (adjusted for transaction costs)							
		Bench.:	2.01			Bench.	+FXS
Carry trade	0.000	0.002	2.20	0.001	0.007	2.07	2.21
FX momentum	0.011	0.019	2.07	0.012	0.020	2.01	2.07
FX value	0.051	0.081	2.07	0.020	0.040	1.99	2.06
All	0.000	0.002	2.28	0.000	0.005	2.04	2.29
Panel B: FX styles based on G10 currencies (adjusted for transaction costs)							
		Bench.:	2.01			Bench.	+FXS
Carry trade	0.060	0.099	2.06	0.026	0.057	1.98	2.04
FX momentum	0.405	0.365	2.02	0.267	0.233	2.01	2.02
FX value	0.037	0.059	2.08	0.037	0.047	2.01	2.08
All	0.082	0.258	2.12	0.049	0.164	1.97	2.10

Table 9: Carry Trade Hedged for Downside Risk

Panel A presents the characteristics of the carry trade (based on G10 currencies) hedged with put and call options. The hedging portfolios are constructed using put and call options such that negative skewness cancels out as described by Burnside, Eichenbaum, Kleshchelski, and Rebelo (2011). Option data are based on implied volatility quotes and are from J.P. Morgan. Quotes are available for 25 delta ("out-of-the-money") and 10 delta ("far out-of-the-money") call and put options. The mean is annualized by multiplying by 12, the standard deviation and the Sharpe ratio (SR) are annualized by multiplying by $\sqrt{12}$. Panel B displays mean-variance efficiency tests for the hedged carry trade strategies as described in Table 2. The benchmark assets are global bonds and global stocks (K=20). The sample period is 07/1997 - 12/2011.

Panel A: Risk and return characteristics

Carry trade hedged with put and call options (G10 currencies, 07/1997 - 12/2011)

	Mean	Std	Skew	SR
Carry trade	4.48	8.11	-0.43	0.55
Carry + 10 delta	3.45	7.27	-0.11	0.47
Carry + 25 delta	2.68	6.69	0.07	0.40

Panel B: Mean-variance efficiency tests

Benchmark: Global bonds and global stocks (07/1997 - 12/2011)

	full hedge $\widetilde{\boldsymbol{\Psi}}_{RM} = -\mathbf{1_j}$			optimal hedge $\widetilde{\boldsymbol{\Psi}}_{RM} = -\mathbf{B_{RX}}$			conditional optimal $\widetilde{\boldsymbol{\Psi}}_{RM} = [-\mathbf{B_{RX}}, -\mathbf{B_{RZ}}]'$			
	W p-value	SDF p-value	Sharpe ratio	W p-value	SDF p-value	Sharpe ratio	W p-value	SDF p-value	Sharpe ratio	
		Bench.:	1.55		Bench.:	1.59			Bench.	+FXS
Carry trade	0.033	0.047	1.66	0.047	0.080	1.69	0.050	0.081	1.66	1.75
Carry + 10 delta	0.094	0.110	1.62	0.098	0.099	1.67	0.103	0.098	1.61	1.67
Carry + 25 delta	0.113	0.119	1.60	0.118	0.107	1.65	0.151	0.135	1.61	1.66

Table 10: Diversified FX Investment Styles

Panel A shows the characteristics of equally weighted FX style portfolios. The mean is annualized by multiplying by 12, the standard deviation and the Sharpe ratio (SR) are annualized by multiplying by $\sqrt{12}$. Panel B displays mean-variance efficiency tests as described in Table 2. The benchmark assets are global bonds and global stocks (K=20). The sample period is 02/1981 - 12/2011.

Panel A: Risk and return characteristics

Equally weighted carry trade (C), FX momentum (M) and FX value (V) strategies

	all currencies				G10 currencies			
	Mean	Std	Skew	SR	Mean	Std	Skew	SR
C+M (EW)	4.73	5.39	-0.01	0.88	3.31	6.46	-0.47	0.51
C+V (EW)	4.74	5.16	-0.88	0.92	4.45	6.17	-0.96	0.72
M+V (EW)	3.81	5.34	0.23	0.71	3.05	6.33	0.53	0.48
C+M+V (EW)	4.43	4.40	-0.03	1.00	3.60	5.39	-0.32	0.67

Panel B: Mean-variance efficiency tests

Benchmark: Global bonds and global stocks

	full hedge $\widetilde{\mathbf{\Psi}}_{RM} = -\mathbf{1_j}$			optimal hedge $\widetilde{\mathbf{\Psi}}_{RM} = -\mathbf{B_{RX}}$			conditional optimal $\widetilde{\mathbf{\Psi}}_{RM} = [-\mathbf{B_{RX}}, -\mathbf{B_{RZ}}]'$			
	W	SDF	Sharpe	W	SDF	Sharpe	W	SDF	Sharpe	
	p-value		ratio	p-value		ratio	p-value		ratio	
FX styles based on all currencies										
		Bench.:	1.17		Bench.:	1.20			Bench.	+FXS
C+M (EW)	0.000	0.000	1.52	0.000	0.000	1.54	0.000	0.000	1.27	1.54
C+V (EW)	0.000	0.000	1.52	0.000	0.001	1.52	0.000	0.001	1.22	1.52
M+V (EW)	0.000	0.000	1.35	0.000	0.000	1.39	0.000	0.000	1.19	1.39
C+M+V (EW)	0.000	0.000	1.57	0.000	0.000	1.59	0.000	0.000	1.23	1.59
FX styles based on G10 currencies										
		Bench.:	1.17		Bench.:	1.20			Bench.	+FXS
C+M (EW)	0.002	0.004	1.31	0.005	0.008	1.32	0.007	0.012	1.21	1.32
C+V (EW)	0.000	0.001	1.41	0.000	0.005	1.39	0.000	0.005	1.19	1.39
M+V (EW)	0.019	0.019	1.25	0.019	0.019	1.28	0.015	0.014	1.19	1.28
C+M+V (EW)	0.001	0.001	1.36	0.001	0.003	1.37	0.001	0.003	1.20	1.37

Table 11: Market States and Out-of-Sample Sharpe Ratios

We split our out-of-sample asset allocations covering global bonds and global stocks with and without FX investment styles (as described in Table 5) into three equally large subsamples of UP, FLAT, and DOWN market states. First, following Cooper, Gutierrez, and Hameed (2004), we define UP markets following months with the highest cumulative 36-month global stock market returns. DOWN markets are defined as months following the lowest cumulative 36-month global stock market returns. FLAT markets are defined as all other observations. Second, we use the previous month's Year-on-Year (YoY) change of global industrial production (IP) as a macroeconomic conditioning variable to define market states. The resulting assignment of months to market states for both conditioning variables is shown in Figure 4. We report HAC t-statistics for the difference in Sharpe ratios ($\triangle SR$) between the benchmark allocations and the test portfolio allocations in brackets. The sample period is 02/1981 - 12/2011. We use the first 120 observations to find the initial portfolio weights for the optimized portfolios. All portfolio performance results, also for naive portfolios, are based on the sample period 02/1991 - 12/2011 (251 observations, 84 (83) for each market state).

	Benchmark: Global bonds and global stocks (fully hedged)							
	36-month stock market returns				Global IP growth (YoY)			
	naive		mv-ssc		naive		mv-ssc	
	Sharpe ratio	$t_{\triangle SR}$	Sharpe ratio	$t_{\triangle SR}$	Sharpe ratio	$t_{\triangle SR}$	Sharpe ratio	$t_{\triangle SR}$
Panel A:	UP markets							
Bench. Sharpe ratio:	0.80		0.29		1.06		1.13	
Carry trade	1.04	[1.30]	0.62	[1.70]	1.09	[0.14]	1.35	[1.13]
FX momentum	1.04	[1.32]	0.55	[1.54]	1.22	[0.79]	1.21	[0.51]
FX value	0.86	[0.42]	0.36	[0.38]	0.98	[-0.42]	1.04	[-0.48]
All	1.06	[2.59]	0.82	[2.06]	1.21	[1.51]	1.42	[1.16]
Panel B:	FLAT markets							
Bench. Sharpe ratio:	0.58		0.95		0.85		0.50	
Carry trade	0.93	[1.75]	1.32	[1.70]	1.32	[2.66]	0.87	[2.18]
FX momentum	0.63	[0.27]	0.98	[0.30]	1.03	[1.23]	0.60	[1.11]
FX value	0.75	[0.90]	1.07	[0.85]	1.13	[1.72]	0.80	[1.96]
All	0.84	[2.24]	1.32	[1.63]	1.22	[3.68]	1.04	[2.46]
	DOWN markets							
Bench. Sharpe ratio:	0.53		1.15		0.13		0.67	
Carry trade	0.68	[1.06]	1.44	[1.24]	0.34	[1.28]	1.11	[1.63]
FX momentum	0.78	[1.53]	1.18	[0.13]	0.29	[0.84]	0.82	[0.86]
FX value	0.92	[2.74]	1.50	[1.99]	0.53	[2.77]	1.06	[2.51]
All	0.84	[3.47]	1.76	[2.34]	0.41	[2.83]	1.42	[2.57]

Figure 1: Cumulative Returns of FX Styles

The figure shows cumulative returns for three FX styles: The carry trade, FX momentum, and FX value. The returns are reported before and after adjusting for transaction costs due to portfolio re-balancing using bid-ask spreads ("ba-adj."). FX styles are based on up to 30 currencies or the G10 currencies. The sample period is 02/1981 - 12/2011.

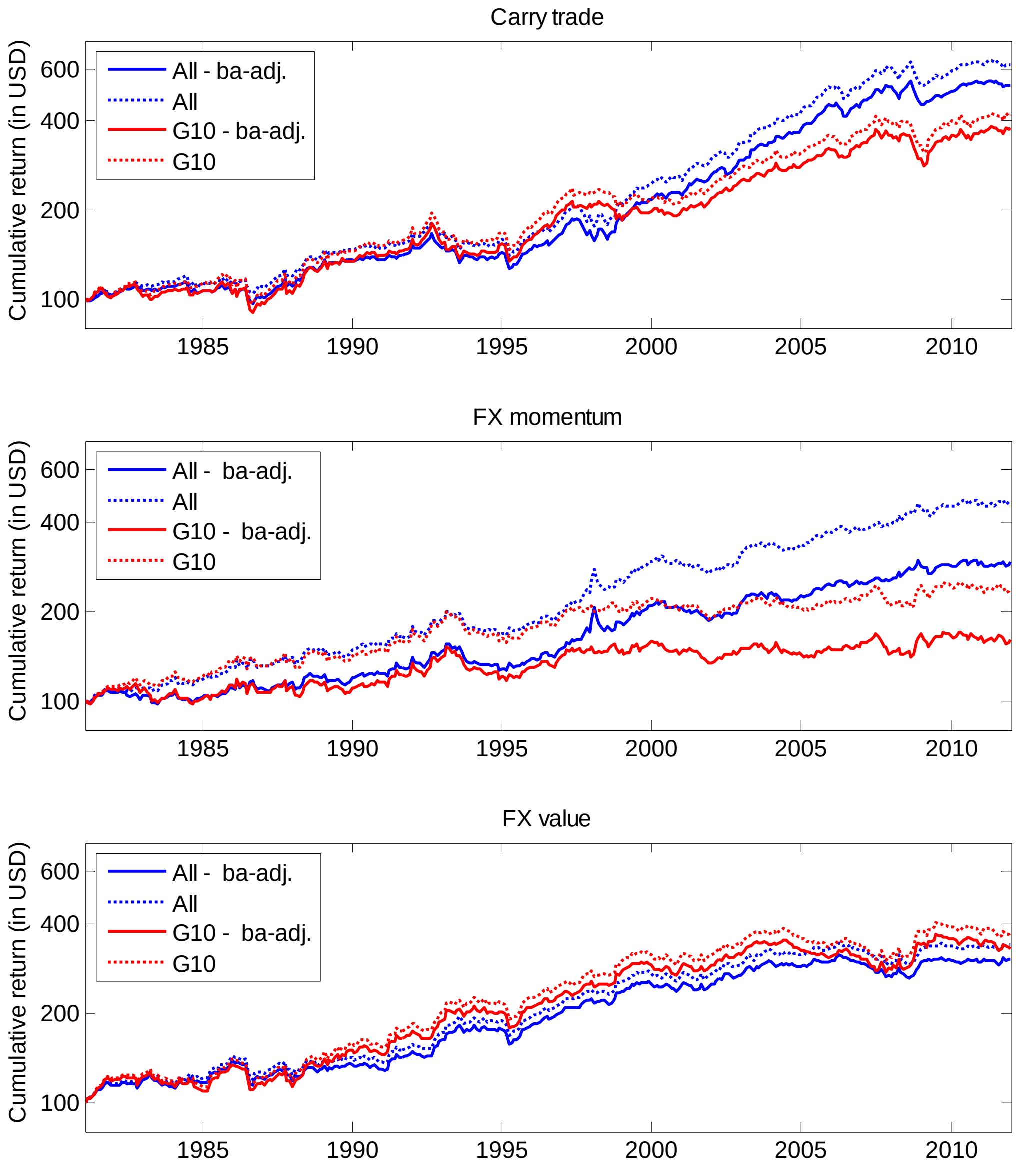

Figure 2: Overview on Baseline Results

The figure summarizes the increases of the Sharpe ratios (in %) when all three FX investment styles are added to a benchmark of global bonds and global stocks, given the different specifications of the Tables 2, 4 and 5. Out-of-sample results are based on the mean-variance portfolio formation rule with imposing short-sales constraints.

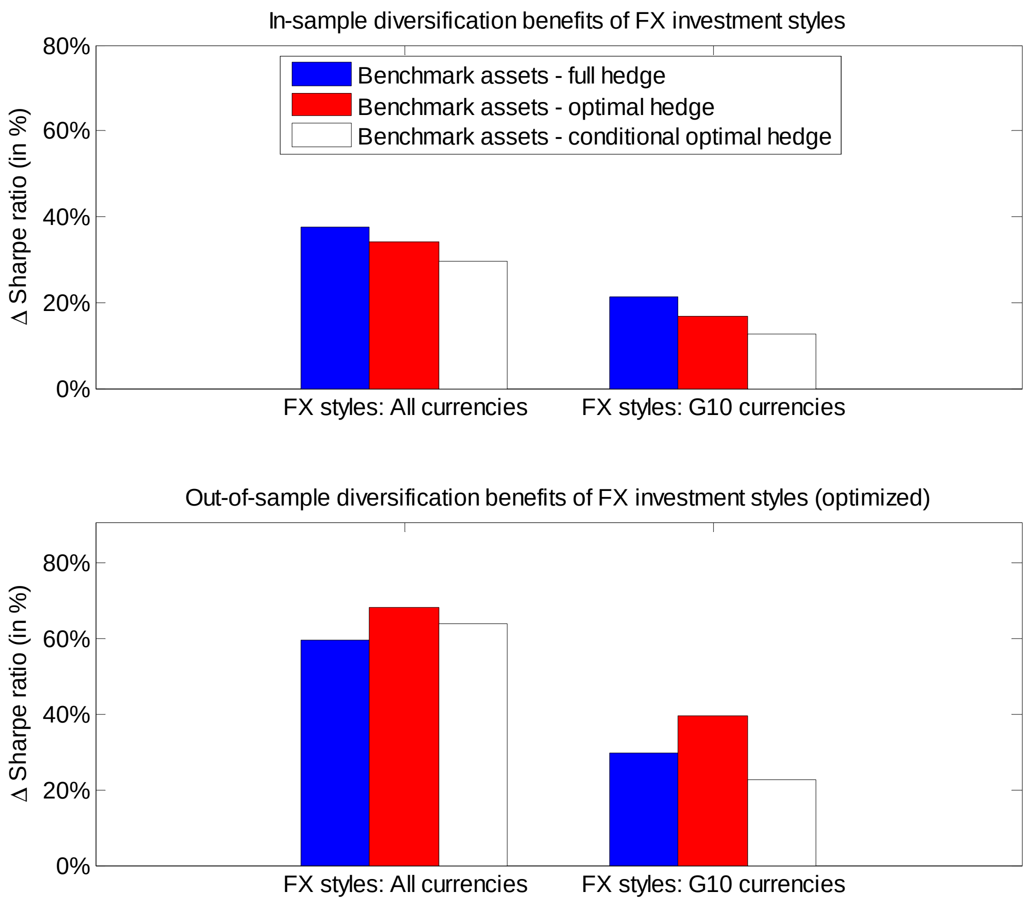

Figure 3: Option-based Gauges of FX Style Risk

The table shows the (ex ante) model free implied volatility, skewness, and kurtosis of the G10 currencies weighted by the portfolio positions of three FX styles. The model free implied moments for each of the G10 currencies are calculated using option prices as proposed by Bakshi, Kapadia, and Madan (2003). The sample period is from 07/1997 to 12/2011.

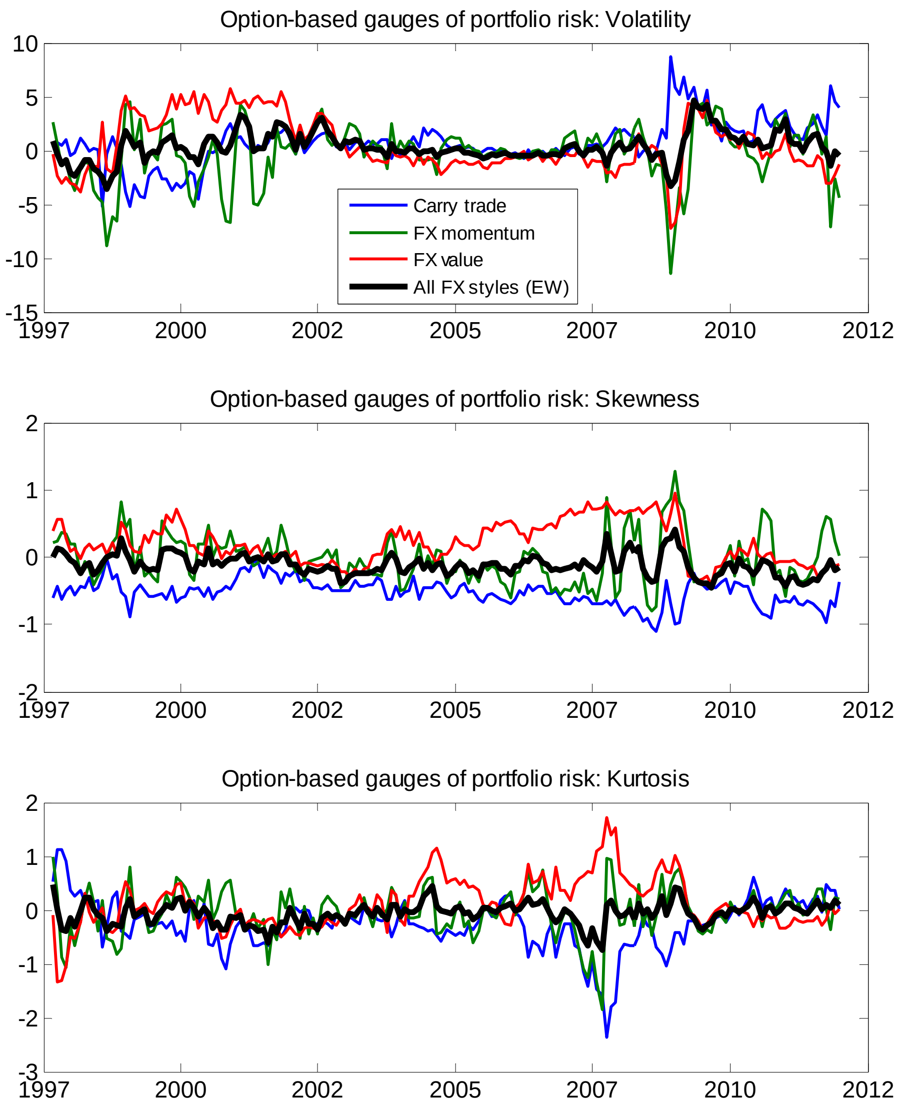

Figure 4: Market States

The figure shows how the sample of out-of-sample returns is split into UP, FLAT, or DOWN market states. We use two variables to define market states, one financial and one macroeconomic, and form equally large subsamples based on the one month lagged realization of the variable. Following Cooper, Gutierrez, and Hameed (2004), the first variable is the 36-month cumulative global stock market return, where UP markets are defined based on the highest 1/3 realizations and DOWN markets based on the lowest 1/3 realizations. The global stock market return is GDP at PPP weighted and fully currency hedged. As macroeconomic variable, we use the year on year change of global industrial production (GDP at PPP weighted). The sample period is 02/1991 - 12/2011.